Sixty-Two Experiments In Crops

Charles L. Quear

"ALL MAY DO WHAT HAS BY MAN BEEN DONE."

SIXTY-TWO EXPERIMENTS IN CROPS

A Laboratory Manual for Beginning Students

By

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PREFACE

THE teacher who is teaching Agriculture in the seventh and eighth grades or the high schools is handicapped by the dearth of information as to what course of study to use and what text books are best suited to this type of teaching. It has been the practice of teachers and school men without agricultural training to adopt some book on general agriculture for exclusive use in teaching the subject. Such practice has caused the presentation of the subject to degenerate into mere "Book Agriculture," with little or no laboratory or field work, and has generally been characterized by farmers and others as aimless, indefinite and impractical. On the other hand teachers trained in agricultural colleges are led, in many cases, to present subjects just as they were taught in the agricultural colleges. In some instances it proved good and was the right thing to do; in many other cases it proved the wrong thing to do.

It was these conditions which prompted the author to devise this series of experiments in farm crops for the seventh, eighth, and ninth grades of the public schools. No doubt there will be many additions and possibly some omissions made by teachers in using this text and adapting it to the points desired to be emphasized in the various schools. In fact this will be necessary before the most effective results can be attained. However, we believe that, in the main, it covers the topics that should be most emphasized in the subject for the grades mentioned. It will, no doubt, be too extensive for a part of the work in the seventh and eighth grades, while for the high school work some supplementary matter may need to be added. Those teachers who find it too extensive may omit those subjects which seem to be of the least value to their community, and take up those of most importance.

Another point borne in mind in writing this text was that a limited amount of money is usually available for laboratory equipment. While this condition is to be regretted, nevertheless the author believes that the small amount of money needed to promote the study successfully will be forthcoming and available. The teachers can raise money for this laboratory work in the same way they raise money for other purposes. Those exercises requiring equipment and for which no money is available at the time may be omitted temporarily and be taken up later as the money is obtained for the purpose.

The first thing that an education should do for a student is to render him capable of making a living and caring for himself. Dewey was not wrong when he stated that an education should socialize an individual—that is, make him an efficient member of society. If this definition forms the basis of an education, agricultural training should undoubtedly form a part of the course of study for the upper grades.

As a large majority, fully 90 per cent, of the girls and boys never go beyond the grades, the necessity of teaching agriculture in the grades becomes the more imperative. Again, since the best agriculture for the future will be that practiced by the boys and girls now on the farm, more strongly urgent are the reasons for presenting agriculture to the boys and girls of the grades.

The author, in presenting the study of crops, has done much to emphasize the above idea. He has begun with the study of chlorophyll and protoplasm, two basic principles necessary for the understanding of botany, biology, physiology, nature study, etc. The sanction for the proper sequential study of agricultural topics is based upon the following psychological principles:

(1) The instincts which characterize the pupil during his adolescent period constitute the basic principle giving sanction to the order of presenting agricultural phenomena.

(2) The ideas and the experiences which the pupil has formerly acquired relate themselves in such a way as to help the pupil in the clear grasp of agricultural facts. This forms the apperceptive basis for such instruction.

(3) The third principle for determining the sequence of presenting topics in agriculture is the economic phase. This determines the pupil's longing for making and owning things and in a sense enhances his usefulness to the human race.

(4) The last basic principle which goes to determine the sequential order of studying agricultural matter lies in the habits previously acquired by the pupil. This is illustrated in his ability to adapt himself to his surroundings. These four principles, if properly understood by the teacher of agriculture, would render him capable of presenting the subject matter in an excellent psychological way.

This manual in crops has followed somewhat carefully the above statement of principles in the order of topics presented. The text can be used for a period of several months' study, and it is fair to state that the subject matter will bear seasonal sequence, whether it be taught during the fall, winter or spring term. The titles of the four divisions of the book corroborate this fact, and they are enumerated here to show their arrangement. The sectional topics are: (1) Plant Composition; (2) Cereal Crops; (3) Forage Crops; (4) Plant Economics.

The manual, we believe, has many points of merit and it will fit into a place in our rural and consolidated schools so as to meet a long felt need.

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EXPERIMENT NUMBER 1.

HOW PLANTS LIVE.—CHLOROPHYLL.

Discussion. While plants and animals consist of cells similar in nature, the common plants differ from animals in the fact that they manufacture their own food. Animals are dependent upon plants for their food supply and plants are in turn dependent upon the green substance found in their bodies to manufacture this food from elements of the soil and air. This gren substance converts the elements brought from the soil and air into nourishment in the presence of light and is called *chlorophyll.* Chlorophyll exists in the cells of plants and usually does not appear unless the plant receives light. Notice that the upper side of a leaf has more color in it than the lower side. The most chlorophyll is in the upper side because there it receives more light. If a plant is put in a dark place the chlorophyll will disappear and in a short time the plant will die from lack of food. The more green matter in a plant the more rapidly the plant produces nourishment and when the green substance begins to disappear it is an indication that the plant is not growing so well. Thus, when corn ripens the base of the stalk loses its green color and food manufacture in that part of the plant ceases. Gradually the green part of the plant disappears and growth entirely stops. To show that chlorophyll is an independent part of the plant and is capable of being removed, perform the following experiment.

Apparatus. A few healthy green leaves; test tube; wood alcohol; iodine, and if convenient a funnel and filter paper. (Iodine solution may be obtained at the drug store and is inexpensive.)

Procedure. Take a few fresh green leaves and place them in a test tube or in a small vessel. Pour hot water over them and let stand for a moment. Pour off the water and at once cover the leaves with wood alcohol. Let them soak in the alcohol until it becomes green, and then pour off the alcohol into a clean white dish. Let the solution stand until the alcohol has evaporated. If a funnel and filter paper may be had filter the solution instead of waiting for it to evaporate.

After the alcohol has been removed by one of the above methods, examine the substance left. This substance is chlorophyll. Pour a drop of iodine solution upon it. Is there any starch present? Sometimes small particles of starch are present in the chlorophyll and may be detected by the iodine test. See Experiment No. 3.

As explained in a later experiment, the plant changes the starch which it makes into other forms of food when the food is needed in the plant tissue. Animal bodies cannot make starch directly from the elements nor can they change starch into muscle building food. This work must be done in the plant. Thus food must become available to animals through the medium of plants.

EXPERIMENT NO. 2.

HOW PLANTS LIVE—PROTOPLASM AND CELLS.

Discussion. All living tissue consists of a substance practically alike, called protoplasm. This protoplasm is the unit of all life and has the power to consume dead material and change it into living substance. Thus the food material made by the chlorophyll, as explained in the previous experiment, is dead material, but is converted into living tissue by the protoplasm. The function of the protoplasm is practically alike in both plant and animal bodies. Protoplasm under the microscope resembles the white of an egg in appearance. Each bit of protoplasm is a unit within itself and together with its nucleus and watery cell sap is contained within a membrane called the cell wall. The entire compartment is referred to as a cell.

Some living objects, as certain bacteria, consist of one cell, while others, as a horse or a cow, consist of millions of cells, each cell having the same essential characteristics as the one cell of the bacterium. Any object that grows does so by multiplying the number of its cells, the cells of a large plant or animal being, as a rule, no larger than the cells of a small one of the same species. In the following experiment let us examine a cell, the unit of all living tissue, whether plant or animal.

Apparatus. Microscope or magnifying glass; some large beans as castor beans or lima beans; solution of iodine; solution of eosin; tin cup; tin pan, and a source of heat.

Procedure. The cells in the seed of the lima bean are rather large and may be seen under the magnifying glass. Cut a thin section of the seed of either the castor bean or the lima bean and examine it under the magnifier. Make a drawing to show the cells. How does the seed grow? Are the cells larger in a large seed than in a small one? Find out by examining both small and large seeds of the same variety under the microscope. How do you account for the difference in size between seeds of the same variety?

To show the protoplasm proper, place sections of the seed in a solution of eosin for a moment. The protoplasm takes up the eosin rapidly and becomes deep red in color, leaving the cell walls and the starch grains unstained. If we place some sections in iodine the starch grains become dark blue and the protoplasm yellow. This action may be readily observed under the microscope. The protoplasm is the source of all activity in the cell and if the protoplasm is killed the seed behaves very differently than when alive. Kill some seeds by placing them in a tin cup and leaving the cup suspended in a pan of boiling water for an hour. Place the dead seeds, together with some that have not been heated, in water and note the difference in growth. Do the seeds whose protoplasm has been killed really grow? Compare the swelling power of dead seeds with the growth of live ones. Is the swelling power of dead material in any sense growth?

In the same manner as above explained examine a section of a potato under the microscope. Observe the starch grains present. Add a drop of weakened iodine solution and note any changes. These starch grains were manufactured by the sunlight and chlorophyll and stored in the potato for the use of the plantlet. About 16 per cent of the potato is starch, stored for the purpose of feeding the new plant when it begins to grow. Explain why the new plant is dependent up this food. Explain the relationship existing between chlorophyll, cells, and protoplasm.*

*NOTE—The active agent in the manufacture of carbohydrates is the chloroplast and consists of chlorophyll, the green pigment and plastid, the living protoplasm. Here the two are considered as one substance under the term chlorophyll.

EXPERIMENT NO. 3.

TESTING SEEDS FOR STARCH.

Discussion. The presence of starch as found in Nature may be easily detected by means of a substance called iodine. Iodine is made from seaweed and the solution which is used consists of the little iodine crystals dissolved in alcohol. Iodine has the peculiar property of turning starch a dark blue. The test is very delicate and a drop of iodine will show the presence of the smallest particle of starch.

Apparatus. Test tube; potato; ground seeds, as finely ground corn meal, flour, etc.; solution of iodine; glass tumbler, and an alcohol lamp.

Procedure. Scrape a little of the potato into a tumbler. Fill the tumbler with water and stir vigorously. Does the potato dissolve? Since the principal part of the solid portion of the potato is starch what may be concluded of the solubility of starch in cold water? Heat the water containing the potato gently over the flame. What change takes place in the color and appearance of the starch? Add a drop or two of iodine to the heated mixture and stir. What change takes place as the mixture cools? Boil the mixture and note that the color disappears. Does it reappear on cooling? Place a drop of iodine on a cut section of a potato. What happens? Test the seeds of various plants in this way and write the results in your notes. Test the back of a postage stamp with iodine. Have the teacher explain this form of starch. Write a discussion upon the sources of starch and its uses.

EXPERIMENT NO. 4.

TESTING PLANTS FOR STARCH.

Discussion. While starch is found in the grain of all plants it also forms the largest part of the solid matter of many vegetables. It is produced in the leaves of plants during the growing season and is deposited in the roots, stems, and seeds.

Apparatus. Green leaves; pan; denatured alcohol, and a solution of iodine.

Procedure. Take a green leaf from a plant late in the evening after it has been in the sunshine or bright light for quite a while. Soak it at once in alcohol until the green coloring matter is removed. Then put it in a solution of iodine and note any change that may occur. What does this change show? Take another leaf from the same plant at six o'clock in the morning and give it the same test. Be careful to keep this leaf in the dark until time for the experiment. Does this leaf reveal any starch? Ask the teacher to explain what has become of the starch. Explain the value of light to the growing plant. Dry carefully and mount the leaves which you have tested.

EXPERIMENT NO. 5.

TESTING PLANT AND ANIMAL SUBSTANCES FOR PROTEIN.

Discussion. The principal food substances in plants are divided into three classes as follows: (a) Protein, (b) Fats or Oils, (c) Starches and Sugars. Protein is the most valuable food in plants and is the most expensive. It is not usually found in large proportions in a vegetable food, but is found chiefly in animal foods as eggs and meats. However, all protein must come originally from plants as explained in Experiment No. 1. For example, the protein in an egg came directly from the food which the hen consumed. The protein in a food is the part which builds up the muscles and gives animals their growth. Young animals especially should have a large quantity of protein food. While protein is rather a complex substance its presence may be readily determined in a food by a simple experiment.

Apparatus. A white dish; the white of an egg; ammonia; a little nitric acid.* and any other substance that you may care to test.

Procedure. Place the white of an egg in a clean white dish. Place a few drops of nitric acid over it and heat the mixture. Note the yellow color that appears. Add a few drops of ammonia. What is the final color? This is the characteristic color test for protein and therefore it shows that an egg contains this substance. In a like manner test a number of other substances. Cut a piece from your finger nail and test it for protein. What is the result? Test various seeds by this method. Beans or peas are good seeds to test. Remove the germ from a kernel of corn and scorch it on the stove. Note the odor. Substances which when burned give off an odor like that of burning feathers contain protein.

*NOTE—Nitric acid is a very strong and dangerous acid. Great care should be taken not to get any on your clothing or body. If you should get the acid on you pour ammonia on the spot at once. Nitric acid and ammonia may be obtained at any drug store.

FIELD EXERCISE—SUGAR IN PLANTS.

Tests have been made of plant substances for starch and how starch is made has been partially explained. The details of the steps a plant undergoes in making starch are not fully known, but it is certain that the plant food before being transported to the various parts of the plant is in the form of sugar and is changed into starch after it has been transported. Sugar is soluble in the cell sap and may be found in the stalk, especially at flowering time. Strip the ears from a good healthy stalk of corn as soon as they are formed, so that the sugar cannot be carried into them. Taste the cell sap in the plant later in the season and it will be observed that it is sweet to the taste the same as sugar cane. Does this suggest any relation between starch and sugar? Name plants that store carbohydrates mainly in the form of starch. Name some that retain their food chiefly in the form of sugar.

EXPERIMENT NO. 6.

TESTING SEEDS FOR FATS AND OILS.

Discussion. Fats as a food furnish heat and energy to the body the same as starches and sugars. However, they are more valuable than starches in that they contain about two and one-fourth times as much food value pound for pound. We can easily determine the presence of fats in seeds by a simple experiment as follows.

Apparatus. Source of heat; piece of white paper; pan, and different seeds to be tested.

Procedure. With a knife scrape a portion of each seed to be tested and place the scrapings on a piece of white paper, keeping each kind in a separate pile. Place the paper in a pan and heat gently from below. What is noticeable that would indicate the presence of oil in the seeds. Write the results in your notes. Which seeds show evidence of containing the most oil? Which the least?

EXPERIMENT NO. 7.

TESTING SEEDS FOR FATS AND OILS.

Discussion. Vegetable oil or fat is a valuable food and in composition it corresponds almost identically with animal fats. They are so nearly alike that we are now using vegetable fats as a substitute for lard and butter with excellent results. Also vegetable fats are used for a variety of other purposes, as olive oil for salads, cotton seed oil and linseed oil for paints, and corn oil for salads, paints, lubricating purposes, as a rubber substitute, etc. Extract the pure fat or oil from some of the above mentioned seeds using the method indicated here.

Apparatus. A small quantity of ether*; ground seeds to be tested; two vessels as glass tumblers; funnel and a finely woven piece of cloth.

Procedure. Obtain some flaxseed meal or cottonseed meal and cover two tablespoonfuls with ether. Pour on enough ether to cover the meal. Stir vigorously for a minute or two. Filter the solution into the other vessel. If you do not have a funnel strain the contents through a closely woven cloth. Let the contents of the vessel set in the open air until the ether has evaporated. It may be readily determined when the ether is gone by the odor. Describe what is left. What is the substance remaining? How is it used by man? Try the same experiment with other seeds, as corn or wheat. Corn is very high in fat, containing 5 per cent. Wheat contains 2 per cent. Write all results in the notes.

A ton of cottonseed will produce about two hundred and eighty pounds of oil, and this oil is extensively used as a substitute for lard in the form of cottolene. Cottonseed oil is also used in oleomargarine.

*NOTE—Do not breathe the fumes of ether any more than necessary. The experiment should not be performed in a tightly closed room. Gasoline may be substituted for ether but ether is to be preferred.

EXPERIMENT NO. 8.

THE MOISTURE REQUIREMENTS OF PLANTS.

Discussion. Probably the lack of moisture limits or cuts short more crops than any other one thing. It is very important to realize the moisture requirements of plants because this impresses upon us the duty of keeping moisture in the soil. In order to appreciate the amount of water a plant needs perform the experiment given here.

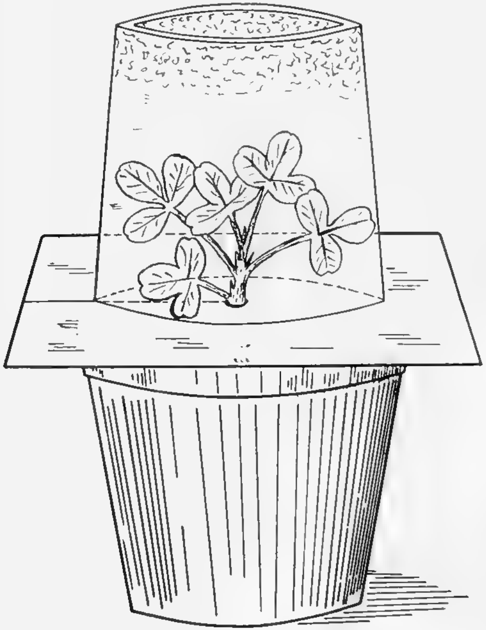


Figure 1.
Transpiration of Plants.

Apparatus. A potted plant which is healthy and growing, as a geranium; a large glass vessel that will go over the plant; a piece of cardboard as large as the flower pot, and some paraffin or tallow.

Procedure. Slit the cardboard from one side to the center and there cut a hole as large as the stem of the plant. Slide the cardboard over the top of the pot and around the stem of the plant. Seal the slot in the cardboard and around the stem with paraffin or tallow so moisture cannot come up from below. Invert a glass vessel over the plant as shown and place the experiment in the sunshine. Observe what happens in a short time. Does the plant retain all of the water taken into the roots? Where does it go? How may the farmer help to keep the water around the roots of the plants in the field? If this little plant gives off enough moisture that you can detect it in such a short time, what may be concluded about the amount of water a large plant will lose?

A healthy corn plant gives off more than a pound of water on a hot summer day. Stop and consider a moment the amount of water passing into the air from an acre of corn each day. It has been estimated to amount to over 900 tons. When you add to this the amount of water passing into the air by evaporation from the soil you will have an idea of the amount of water that is necessary to produce a crop.

What is the importance to be attached to keeping moisture in the soil by cultivation? Write a discussion on "Moisture Requirements of Plants."

EXPERIMENT NO. 9.

TO SHOW THAT MOISTURE PASSES THROUGH A PLANT.

Discussion. Water absorbed by the roots of a plant is forced up through the plant into the leaves. From there part of it goes into the atmosphere and the remainder into all parts of the plant. To show that water goes into all parts of the plant perform the following experiment.

Apparatus. Tumbler; red ink, and freshly cut plant as a white geranium or any stem with a healthy leaf on it.

Procedure. Place the freshly cut stem in a colored solution which may be made by pouring a little red ink into a tumbler of water. Watch the rise and distribution of the coloring matter throughout the entire stem and leaf. This shows you how a plant transports its food. Hold the plant to the light after the colored solution has penetrated all parts of it and notice the hundreds of little veins through which the coloring matter has passed. Compare the way plants obtain food with the way our bodies get food. Compare the way food is transported to the tissue in the plants with the way it is transported through animal bodies. Write three questions about this experiment and discuss them in class. Make a drawing to show the results of this experiment. Colored crayons will aid in making the drawing.

EXPERIMENT NO. 10.

CARBON IN PLANTS.

Discussion. Carbon exists in the air united with oxygen and in this form is called carbon dioxide. A growing plant obtains its carbon from this source, and not from the soil as is popularly supposed. About 80 per cent of a green plant is water, 1 per cent ash, and 19 per cent organic matter. Most of the organic matter is carbon. To show the presence of carbon in plant products perform the experiment given here.

Apparatus. Test tube; alcohol lamp; starch; sugar and a piece of charcoal.

Procedure. Place some sugar in a test tube and heat it. Note the changes that occur. Observe what is left in the test tube. Taste it. Compare the substance remaining with a piece of charcoal. Charcoal is nearly pure carbon. Explain the source from which the sugar came and explain how the plant obtained the carbon. Hold a piece of charcoal in a hot flame. Does it burn?

Repeat the above using a small quantity of starch. Compare the results. What element is shown by these experiments to be present in plant substances? Explain how charcoal is made.

EXPERIMENT NO. 11.

THE EFFECT OF TOO MUCH PLANT FOOD.

Discussion. Usually we do not find a plant suffering from too much plant food, yet this sometimes happens. Occasionally heavy applications of fertilizers do not bring the results expected and we wonder what could be the trouble. Too much plant food in a soil prevents the plant from getting the moisture which it needs and literally starves the plant. If the water around the roots of a plant contains more solids, or food, dissolved in it than the water contains that is in the roots, the water passes from the roots back into the soil and the plant dies.

By a law of nature called osmosis, water will pass from soil to roots or from roots to soil, depending upon which contains the more solid material in solution. The most water passes from the part that contains the least to the part containing the most solids. Thus ordinarily, the plant evaporates water through the leaves until the water in the stem and roots contains a lot of solids. It is just like evaporating "Sugar Water" and getting thick syrup. Then the water in the soil with very little solids dissolved in it passes into the roots just as fast as water is evaporated by the leaves or used by the plant. In this way a continuous stream of water is always flowing through a plant, furnishing it with the necessary elements for food manufacture. But if we place a large amount of soluble material as fertilizers in the soil the water around the roots becomes thicker or denser than the water in the roots and can no longer pass readily into the plant. As a result water passes from the plants back into the soil and the plants die. To demonstrate this principle perform the experiment given below.

Apparatus. Salt; two dishes, and a potato.

Procedure. Peel the potato and cut it into a number of rather small chunks. Place half of the pieces in a dish of clear cool water. Place the remainder of the pieces in the other dish and cover with strong salt water. After an hour or two examine the pieces in each dish.

Notice that the pieces in the clear water are firm and solid, which shows that they contain as much or more water than they did at first. Examine the pieces that were in the strong salt water. Notice that they are soft and flabby. Water has left them and gone into the strong salt water. The salt represents the soluble fertilizers in the soil water, and shows you that water leaves plant substance if the soil water contains too much solids in solution. It is in this manner that we kill plants by a heavy application of salt. A little salt will often help a plant, but too much will certainly kill it.

An average plant will live in a soil where there is only one part of solid material in 1,000 parts of water and will die if there is more than one part of solid material dissolved in 100 parts of water. Generally less than this amount will kill it. At home, try killing some plants with salt. Try putting only a small amount of salt around a plant and see what effect it will have. Try the same experiment with commercial fertilizers. Write all results in your notes.

EXPERIMENT NO. 12.

SOIL WATER IN RELATION TO PLANT COMPOSITION.

Discussion. In more than half the area of the United States there is not enough water available, in the average season, for a maximum yield of crops. In the central part of the United States agricultural plants, on an average, take 450 pounds of water from the soil for every pound of dry matter produced. Therefore it is of greatest importance to find out what plants will produce a pound of dry matter on the least water drawn from the soil. By careful experiments conducted by the United States Department of Agriculture, the number of pounds of water drawn from the soil for every pound of dry matter manufactured, by certain plants, has been ascertained to be as follows:

Millet	275 lbs.	Wheat	507 lbs.
Sorghums	322 lbs.	Oats	614 lbs.
Corn	369 lbs.	Rye	734 lbs.
Potatoes	488 lbs.	Alfalfa	1086 lbs.

From this table it is easy to understand why oats require a moist climate as compared with millet. Of all agricultural plants tested alfalfa requires the most water. However, alfalfa is usually the last to suffer from drought, since its deep branching roots feed through a greater area of soil than other plants.

Apparatus. Seeds of corn, millet, alfalfa, wheat, oats, rye, a potato, and a pot of clean fine soil for each kind of seed.

Procedure. Plant seed of each kind in a separate pot and moisten thoroughly. Keep the pots of seed in a warm light place and give them plenty of moisture. When they are all up nicely thin them so that each pot contains about the same amount of plant growth and cease watering them. Note results from day to day. When each pot of plants is almost dead from lack of moisture record the number of days it has existed and the growth made. At this time give each pot of soil a good soaking with water and again leave it as long as the plants will live without watering. Which plants seem to stand drought best? Is the explanation apparent? Did the plants recover their former vitality after watering them? Which showed results first? Which last? Did some plants of the same kind show variability as to their drought resisting powers? Does this experiment open any possibilities as to the methods for adapting crops to different climates?

EXPERIMENT NO. 13.

OSMOSIS.

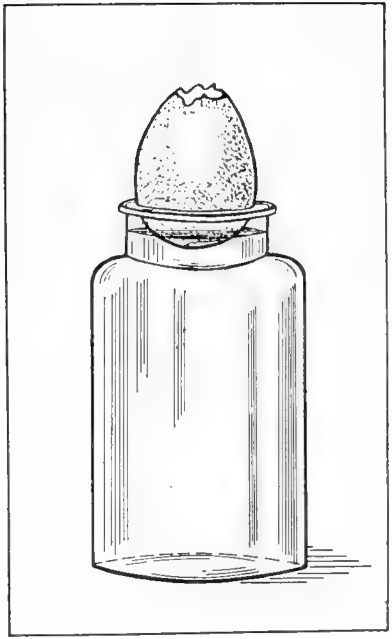


Figure No. 2.
Osmosis.

Discussion. The process of osmosis explained in Experiment No. 11 may be thoroughly demonstrated by this experiment.

Apparatus. An egg; a large mouthed bottle; red ink; and some sugar.

Procedure. Select a bottle which will permit an egg to partly enter the mouth as shown in Figure No. 2. Carefully remove the shell from the large end of the egg without breaking the skin, or membrane, lying just under the shell. Make a small hole, about the size of a dime, in the little end of the egg. Rinse the interior of the egg thoroughly and fill with clean water. Fill the bottle with water colored red, either by means of dye or red ink, and place the egg in the mouth of the bottle as shown. Observe the water inside of the egg from time to time. What happens?

Empty the egg; rinse it out again and fill it entirely full of a strong solution of sugar and water. Cleanse the bottle and fill it with pure water and again place the egg in the mouth of the bottle. Note what happens. Can you explain why the water runs out of the egg? As previously explained, this process is called osmosis. The colored liquid in the bottle passed into the egg as did the water into the sugar solution. Taste the water in the bottle. Can you account for the sweet taste? Which took place the more rapidly, the water passing into the sugar solution or the sugar solution passing in o the water? Why?

When seeds swell and burst their coats much the same thing has happened. The carbohydrates in the seeds take up water until the interior of the seeds swell to the bursting point.

EXPERIMENT NO. 14.

CELLULOSE IN PLANTS.

Discussion. Cellulose or plant fiber is the principal part of the framework of all plants. In its use to plants it is similar to the bones of animals. Wood, cotton, linen, and paper are largely cellulose. Pure cellulose is white and if properly treated may be converted into alcohol. Dry cellulose is practically indigestible to animals and for this reason is almost worthless as an animal food. A good example of cellulose is the seed coat of a corn kernel.

Probably at some future date cellulose can be changed into alcohol at a price low enough to make the industry profitable. When science is able to use this cellulose and change it into wood alcohol cheaply, another step will have been taken towards utilizing our resources. It is said that there could be enough wood alcohol extracted from an acre of corn stalks to light a modern home for a year. To understand the appearance of plant fiber examine some cotton, flax, and hemp. These substances are almost pure plant fiber. In accordance with the following experiment remove cellulose from a plant.

Apparatus. Substance to be tested, as alfalfa or clover stems; sulphuric acid; sodium hydroxide; two glass vessels or test tubes that may be heated, and a tin pan.

Procedure. Cut fine and mix with a little water the stems of the plant to be tested. Place about one-fourth of a hand full of these stems in water and add a little sulphuric acid, enough that you will have a solution of about two parts water to one part acid. The water and acid should more than cover the plant stems. Heat the substance gently and let it stand for about thirty minutes. Then pour off the water and acid, but retain the solid material which remains. Wash the solid material by rinsing it with pure water. Place the solid material in a clean vessel and pour over it a little sodium hydroxide solution. After it has stood for about five minutes pour off the sodium hydroxide and wash the substance again thoroughly. Place the solid material in an oven and heat slowly until all the moisture is driven off. The substance remaining in the pan is largely cellulose. Describe it. What is its color? Why is it not white, as cotton. If you have at any time heated the mixture until it boiled some of the cellulose will have been changed into glucose, a sticky substance somewhat similar to molasses. Write a discussion upon the value of cellulose or plant fiber as a food for animals.

EXPERIMENT NO. 15.

PHYSICAL EXAMINATION OF THE CORN KERNEL.

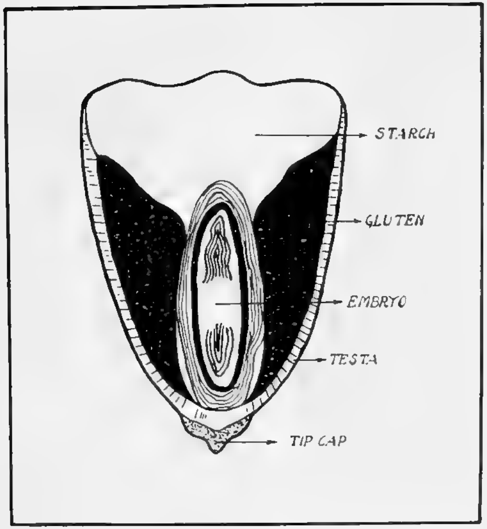


Figure No. 3.

Parts of a Corn Kernel.

Discussion. To determine the composition of corn by a physical means separate the kernels into four main parts as follows:

(1) Gluten. The part which we call gluten includes all of the kernel except the covering, the white powdery starch, and the germ or embryo. Although it is not pure gluten it is high in protein and for this reason is a valuable part of the kernel.

(2) Hull. The hull is the seed coat or covering. It is referred to as the Testa.

(3) Starch. The starch is the white crumbly part of the kernel.

(4) Embryo. The embryo or germ is that oily part of the kernel which contains the little plantlet. It lies just under the hull on the concave side of the kernel and, if the kernel is a normal one, it extends from the tip of the kernel about three-fourths of its length.

Apparatus. A pair of balances which will weigh in grams; a sharp pocket knife, and yellow corn kernels soaked in water for twelve hours or more. (It is easier to dissect yellow corn kernels than white ones for the reason that you have color to help distinguish between the protein containing part and the starchy portion.

Procedure. Remove the covering that is around the entire kernel by carefully peeling it. This covering is the hull and in this exercise includes what is commonly called the tip cap—the part that attaches the kernel to the cob. Place the hull in the square on the opposite page marked Testa. Carefully remove all of the yellow portion of the kernel and place it in the square marked Gluten. It is this part that is high in protein content. Carefully cut out the germ, which is the oily portion, and place it in the square marked Germ. Remove any starch that may stick to the germ by carefully scraping it from the surface. All of the remainder of the kernel is starch. It should be placed in the square marked Starch.

Repeat the operation with four more kernels. Weigh each part of the five kernels separately—that is, weigh the five hulls together, etc. From this figure the percentage of the kernel that properly belongs to each part. Remember that the protein containing material is the portion which builds muscle in the animal, replaces torn down tissue, and is especially valuable.

The germ is next in value for the oil and protein which it contains, the oil being worth two and one-fourth times as much as the starch. Approximately four-fifths of the oil and one-fifth of the protein is found in the germ. Therefore, we want kernels with as much protein containing material as possible and with as little starch as we can get, so long as this end may be reached without lowering the yield of corn. Can you tell why this is true? Cut kernels of corn as shown in Figure No. 3 and compare them. Can you tell which are the best kernels from the standpoint of their feeding value?

Kernels may be roughly compared as to the amount of the above parts which they contain by holding them to the light. Kernels having a large amount of protein containing material can be readily determined, for the light shines through the protein substance, but not through the starch. When feeding value is considered it would be worth while to examine every ear of corn in this manner and select for seed only those ears having a large amount of protein containing material and containing large germs.

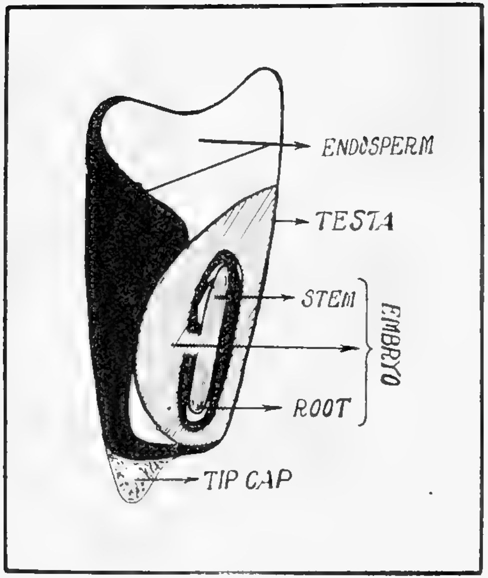
NOTE—If no delicate balances are to be had for this exercise, have each pupil dissect only one kernel and glue the parts of it in squares shown below. The above exercise opens a field of discussion on which there is a difference of opinion. If possible the class should consult other literature upon the divisions of the corn kernel and the comparative value of the parts.

TESTA	*GLUTEN*
STARCH	*EMBRYO*

NOTES:

EXPERIMENT NO. 16.

THE PARTS OF A SEED.



Parts of a Seed.
Figure No. 5.

Discussion. In the previous lesson corn kernels were divided on basis of their composition, but in this exercise the kernels are to be examined on basis of their parts as classified relative to the nature of the seed. In botany the corn kernel is usually divided into the following parts: (1) *Endosperm.* The endosperm is the entire hard outer portion as shown in Figure No. 5. It furnishes most of the food for the little seedling when it begins to grow. (2) *Hull.* The hull is the thin seed coat entirely surrouding the kernel. (3) *Embryo.* The depression near the center of the kernel discloses an oily soft portion of the kernel usually extending about three-fourths of its length and showing on only one side of the kernel. This embryo includes the little plantlet proper, which can be easily removed, as it is just at the surface of the oily portion of the kernel. After taking the little plantlet from the embryo the remainder of the embryo is called *cotyledon.* Remember that the cotyledon is the portion in direct contact with the little plantlet and is a part of the embryo. In the corn kernel notice that there is only one cotyledon.

Apparatus. Dry corn kernels, preferably yellow; corn kernels and beans that have been soaked in water over night; a sharp knife and a magnifier if one is obtainable.

Procedure. Examine a dry grain of corn on both faces and sketch the germ side of the kernel, labeling the hard outer yellowish portion "endosperm," and the depression near the center "embryo." Notice a kernel of corn that has been soaked twenty-four hours. How is it different from a dry kernel? Remove the testa by carefully peeling the entire kernel. With the point of a sharp knife carefully remove the little plantlet from the embryo of this soaked kernel. Holding the grooved side up, make a drawing of the kernel that has been soaked and that has had the little plantlet removed. Label the indented portion "cotyledon." This is the part which you labeled embryo before, for the cotyledon is the portion of the embryo remaining after the little plantlet is removed.

Open a bean that has been soaked for twenty-four hours by first removing the seed coat and then splitting it into its halves. Make a drawing of the halves as they lie side by side, showing the little plantlet. Label each half "Cotyledon." Notice that in the bean there are two cotyledons and no endosperm. The entire bean with the exception of the seed coat is the embryo.

By carefully dissecting a number of different kinds of seeds you will become very familiar with the parts of a seed. This work should be carefully done, as the information will be needed later in the work.

EXPERIMENT NO. 17.

THE PURPOSE OF THE PARTS OF THE SEED.

Discussion. The young plant gets its first food from the supply of material which is stored in the seed, tuber, root or other part that is planted. The seed's sole purpose is to protect and feed the embryo plantlet stored within. It must contain enough stored material to supply the young plant until it can send roots into the soil, and until the leaves are formed. It is a great advantage to the little plant if the seed, or part planted, contains enough food to help it along while it is young.

It is interesting to note that there is enough food stored in a bean to last it until it blooms. To demonstrate the value of this stored food is the purpose of this exercise.

Apparatus. Two small flower pots or two tin cans filled with finely screened soil; a few beans and some grains of corn.

Procedure. Plant a few beans in a pot of soil and keep the soil warm and moist. As soon as the leaves appear above the surface of the soil pull out all but two plants and then carefully remove the two half beans or cotyledons (see Experiment No. 16) from one of the plants. Compare the development of the two plants for the next week or two. Explains the result.

Select some healthy corn kernels and carefully remove the germs from a few of them. Plant these germs and also a few entire kernels in a pot of soil. Compare the growth and development of the plants. Explain the results.

EXPERIMENT NO. 18.

COMPOSITION OF PLANT AND ANIMAL PRODUCTS

Discussion. All substances are classified as belonging either to the animal, the vegetable, or the mineral kingdom. Substances belonging to the animal or vegetable kingdom are said to be organic -that is, they are organized substances that have or have had life. This includes all solid substances except the inert rock and mineral compounds found as a part of the earth's crust. These solid substances which occur in the earth's crust are called minerals. Any plant or animal contains some mineral matter. All organic material under proper treatment will pass into the air from whence it came and therefore it is a very easy matter to divide a substance into its mineral and organic constituents.

Apparatus. Balances; potato; two clean tin cups; tin pan; some milk, and a source of heat.

Procedure. Wash a potato until it is thoroughly clean. Weigh it and record the weight. Weigh out an equal amount of milk. Weigh two tin cups and record the weight of each. Into one cup pour the milk and place the potato in the other. After the potato is in the pan chop it up as finely as you can, being careful not to lose any of it. Heat both at a low temperature for several hours. To heat the two cups at a low temperature suspend them in a pan of boiling water. The milk is to be removed from the heat as soon as all of the liquid has evaporated. The potato will have to be heated longer than the milk to drive all of the moisture out of it. At the end of two or three hours weigh each cup with its contents. Subtract the weight of each cup from these weights. Subtract the weight of the dry substance from the weight of the substance at the beginning. The difference is the amount of water which was present in the substances.

Heat each again as hot as possible for an hour or more, with the cups in direct contact with the flame. Reweigh each and subtract the weight of the cups as above. The difference between the weight of the substance after the water was removed and the last weight is the amount of organic that was present. The material which remains is called mineral matter. What percentage of each substance is water? What percentage is organic matter? What percentage is mineral matter? Write all the results of the experiment in your notes, using the form on the opposite page.

COMPOSITION OF PLANT AND ANIMAL PRODUCTS

SUBSTANCE	TOTAL WEIGHT	WEIGHT OF PAN	WEIGHT AFTER 1st. HEATING

PERCENT OF WATER	WEIGHT AFTER 2nd. HEATING	% OF ORGANIC SUBSTANCE	% OF MINERAL SUBSTANCE

FIELD EXERCISE.

Farm Accounts. The farmer should be able to tell at the end of a year what his gain or loss has been and which departments of his business are profitable. This means that he must have a simple and accurate method of bookkeeping. A system of bookkeeping should start with an inventory, which should be made every year. Accounts should be kept with all important branches of the business and a general account should carry all the other items. Prepare an inventory of the home farm, giving every item a reasonable valuation. On ruled sheets of paper start accounts with the various parts of the business and keep the accounts throughout the year.

Much valuable and important information may be gained from such an account, and this exercise should form the basis for a great deal of practical work of interest to pupil, teacher, and parent.

EXPERIMENT NO. 19.

EVOLUTION OF THE CORN PLANT.

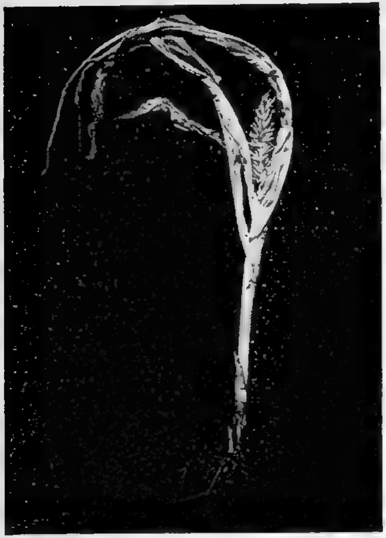


Figure No. 6.

Primitive Tassel Corn.

Discussion. To the best of our knowledge the very first corn plants that existed appeared similar to Figure No. 6. From that time until the present day corn has changed and become larger and better, until today we have the large and almost perfect ears of dent corn as the descendants of the primitive tassel corn. The change the corn plant has undergone during these hundreds of years is known as the "EVOLUTION OF THE CORN PLANT." How different husking corn would be if the present day corn were of the kind shown in Figure 6. Notice that in this corn every kernel is in a pod of its own, and the whole thing looks more like a head of wheat than corn.

If we follow the evolution of corn carefully, we find that first we have tassel corn—the corn in the tassel at the top of the stalk and each kernel in a pod of its own. There is no distinct cob in tassel corn.

The first tassel corn was a mere grass, only a few inches tall, and contained a very few hard seeds not unlike the present day pop corn in appearance. From tassel corn improvement took place and finally pod corn came into existence. In pod corn each kernel is in a pod of its own and there is a cob to which all of the kernels are attached. Usually the ear of pod corn is surrounded by a husk similar to the present day ear of corn.

As nature is constantly producing new plant forms and since the strongest survive, from pod corn flint corn was evolved. Flint corn has round hard kernels, usually making a long slender ear of from twelve to fourteen rows of kernels in circumference. It has no husks surrounding the kernels, but that which was the husk around each kernel in pod corn disappears in flint corn except at the tip of the kernel, where a portion of it remains and is called the tip cap. The tip cap is that portion which attaches the kernel to the cob. Remove some tip caps from kernels of corn and examine. The entire ear of flint corn is surrounded by a husk similar to dent corn, which is another type in the scale of evolution and the most valuable stage of perfection to which the corn plant has been developed. It is from these various stages of evolution that we have all of the present day types of corn which we will discuss in the next experiment.

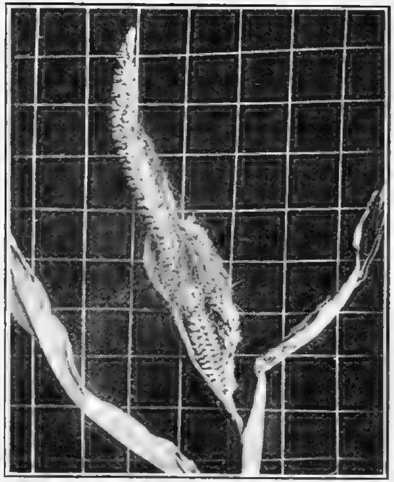


Figure No. 7.

Reversion Toward the Primitive Tassel Corn.

Apparatus. A field of corn that is almost mature; some large sheets of cardboard for mounting purposes, and some wire, as picture cord, for fastening the specimens to the cardboard.

Procedure. When ears of corn like those shown in Figures No. 6 and 7 are found it is usually said that a "Freak" has been found. Such ears are not freaks, but merely the attempt of Nature to produce the form of plant which she produced many years ago. The correct term for describing such an occurrence is to call such an ear a "Reversion." If you will carefully examine the stalk of corn in the field you will find some that have produced these primitive types. Nature is continually trying to produce these primitive kinds of corn and our fine dent corn only remains dent corn because we carefully select the seed each year. If no attention were paid to the selection of seed corn it would not be long until there would be pod corn and tassel corn in abundance.

If a great many of the different primitive kinds of corn, or reversions are found in the field being inspected it may indicate that the seed which the farmer planted was not properly selected. The seed is not the only factor in producing reversions, but it is one of the most important conditions. A more detailed study of this subject should be pursued if time may be had.

Make a collection of these various types of evolution and mount the specimens on cardboard to hang in the school room. Arrange the specimens so they show the evolution of corn, step by step, from tassel corn to dent corn. Is it any wonder that dent corn, which has undergone such a wonderful change, is now called the King of the Cereals?

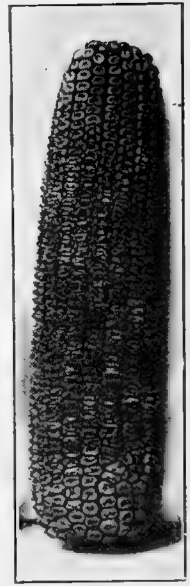


Figure No. 8

A Modern Ear of Dent Corn.

EXPERIMENT NO. 20.

TYPES OF CORN.

Discussion. To understand the value of pure seed we must understand the various types of corn, as well as their place in evolution as explained in Experiment No. 19. The most important questions regarding seed corn are: (1) Will it grow? (2) If it grows will it produce? Of the two questions the last one is of as much if not more importance than the first. When a kernel of corn fails to grow the other kernels around it that do grow obtain the food which it would have obtained and there is not a great deal of loss to the farmer. But if the kernel grows and produces a barren stalk, or a primitive type of corn, it would have been better if the kernel had never been planted. Not only does it consume food which the other plants might use, but the pollen from the primitive plant fertilizes the good plants all around it and makes them worthless for seed corn.

Figure No. 9.
Pod Corn.

Apparatus. A mature field of corn.

Procedure. When a "type" of corn is spoken of, a group of plants is referred to which has certain characteristics that set them apart from all other corn plants. On basis of this division we have the following types.

(1) Tassel Corn. In tassel corn the kernels appear in the tassel each in a separate pod, and without a well defined cob. See Figure No. 6. Tassel corn is not usually classified as a type of corn, but it will be so considered here.

(2) Pod Corn. In pod corn each kernel is in a pod and the pods are on a central axis which we call a cob. Usually the entire ear of corn is surrounded by an outer husk similar to the husk of the present day corn. See Figure No. 9.

(3) Flint Corn. Flint corn has round hard kernels, a long slender cob, usually twelve to fourteen rows of corn on the cob and has husks surrounding the entire ear. See Figure No. 10.

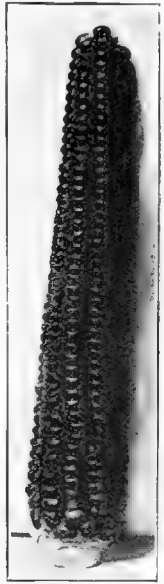


Figure No. 10.
Flint Corn.

(4) Pop Corn. Pop corn is a dwarf type of corn, with small hard kernels. It has the peculiar property of turning wrong side out when exposed to heat. This is due to the sudden expansion of the moisture when heated, which explodes the hard corneous endosperm.

(5) Sweet Corn. Sweet corn is similar to dent corn except that a large percentage of the sugar in the kernel is not changed to starch upon ripening. Usually sweet corn is desired early and the constant selection of early varieties has somewhat diminished the size of sweet corn.

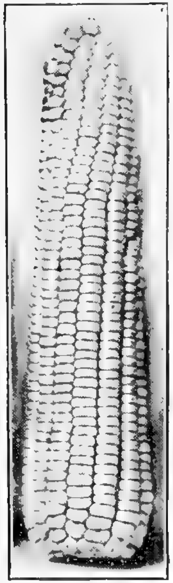


Figure No. 11.

Soft Corn.

(6) Soft Corn. Soft corn, like pod corn, is not grown as a staple crop in the United States. This was the principal corn used by the American Indians, and was favored by them because it was very easily ground. The stalks of this corn are long and the ears numerous on the stalk. The kernels are very large, white, and soft. Its softness is caused by the fact that its endosperm is of soft white starch, wholly lacking the hard portions of the other types. This corn is sometimes grown in the corn belt states as a silage crop. It does not mature in these states, but makes a rank growth and produces a great deal of silage. See Figure No. 11.

(7) Dent Corn. The dent corn in its various varieties is the highest type in the evolution of the plant, although it may have been developed simultaneously with other types. It is only held to the standard of perfection which it has now attained by constant and careful selection of seed. It follows, therefore, that we must know, not only that the seed will grow, but how well it will produce.

(8) Kafir. Botanically kafir is not really a member of the corn family, but belongs to the sorghums. For agricultural purposes, however, kafir may be considered a type of corn. Its medium sized seeds grow in a cylindrical or oblong head instead of an ear. Kafir is grown principally in the semi-arid regions of the Southwest. It is a good substitute for corn in the ration of all farm animals.

Collect ears of corn that represent the above types. Examine the corn in the field for the following characteristics: Ears that are double tipped; stalks with a number of ears on the stalk—five or more; ears with very large cobs and small round kernels; cobs well formed with kernels missing, etc. Explain what all such characteristics indicate.

EXPERIMENT NO. 21.

VITALITY AS IT AFFECTS YIELD IN CORN.

Discussion. There are many conditions which influence the yield of corn per acre and some of them can be readily detected. Close examination shows that in many cases the stand of corn is not good, which may indicate that the farmer has used seed that was not strong and healthy. Such seed is said to be "Low in Vitality." This is a wholly preventable cause for a poor corn yield and should be eliminated from the factors that tend to produce decreased yields. It is only by using seed of strong vitality that we can hope to get a good stand of corn.

Also the number and size of the ears on the stalk varies to a great degree. It is important that every stalk have at least one large well formed ear. If the ears are small and ill formed the indication is that the soil is poor. If there are many stalks without ears, called barren stalks, seed for the next year should never be selected from that field.

If corn is planted one kernel at a place (drilled), the plants should be from ten to twenty-four inches apart in the row. If the corn is planted in hills (checkrowed), there should be from two to four plants in the hill depending upon the fertility of the soil, amount of moisture, etc.

Apparatus. Measuring stick or tape measure; spring balances, and a bag or bushel basket.

Procedure. Find a row of corn that represents the average of the field and measure along this row a distance of one hundred and twenty-five feet. If the rows of corn are three and one-half feet apart, the distance measured represents one hundredth part of an acre. From this row determine the following and write all results in the blank spaces provided.

How many stalks would there be in the row if the stand were perfect? (Count the stalks eighteen inches apart if drilled and three stalks to the hill if checked). What is the actual number of stalks? What percentage of a perfect stand does the row show? What is the number of barren stalks? What is the total weight of the corn in the row? Counting 72 lbs. to the bushel, what would be the yield of the field per acre? If the stand were perfect and each stalk produced one ear of average weight, what would be the yield per acre? How does this compare with the actual yield? If possible, compare the yield as figured with the actual yield as it weighs out when the farmer husks the corn. Do you see any relation between Vitality of Seed and Yield per Acre?

Number of stalks in row if stand were perfect..	....
Actual number of stalks in the row..	....
Percentage of a perfect stand..	....
Total number of barren stalks..	....
Percentage of barren stalks..	....
Total weight of corn in the row..	....
Total yield in bushels per acre..	....
Total number of ears in the row..	....
Average weight per ear..	....
Perfect yield per acre..	....
Yield per acre when husked..	....

EXPERIMENT NO. 22.

POLLINATION OF CORN.

Discussion. The flowers of the corn plant are quite wonderful and beautiful when you understand their purpose. The flowers are found at two places on the stalk, at the top and at the ear. See Figure No. 23. The flowers at the top of the stalk are called the tassel. Those at the ear are called the silks. The silk is not an entire flower but merely the stigma attached to the ovary at the cob. The tassel of corn contains thousands of small yellow dust-like particles called pollen, which when ripe fall or are carried to the silks of the corn and cling to the sticky silks. When a pollen grain lights on a corn silk that is sticky,—or ripe as it is called, the pollen at once begins to grow and penetrates the entire length of the long slender silk. When the pollen grain reaches the base of the silk, or ovary, it unites with the ovule and this union produces a small corn kernel which at once begins to grow. When this happens the kernel is said to be "fertilized," or pollinated. Every kernel has one corn silk attached to it. The butt kernels are fertilized first and the tip kernels last. Often the tip kernel silks ripen so late that they are not fertilized and no kernels are produced at the tip of the ear. Sometimes insects destroy the silks and the kernels cannot be pollinated Discuss pollination of corn and examine for the points mentioned as follows.

Apparatus. Tassel of corn containing pollen; immature ears of corn with silks attached; corn kernels; cardboard for mounting specimens; magnifying glass; paper bag and string.

Procedure. Examine pollen grains under the magnifier. Describe them. Shake out all the pollen possible from a tassel and note the amount. Is there likely to be a scarcity of pollen? Examine one of the little sacs which contains the pollen. How does the pollen escape from the sacs? Note where the corn silks are attached to the kernels. Examine ears of corn for kernels that have not been pollinated and, therefore, have not developed. What happens if the pollen from one kind of corn lights on the silks of another variety of corn?

Go into the field of corn just at the time the tassels are beginning to put forth and find an ear that is almost ready to put forth silks. Tie a paper bag over the ear in such a manner that no pollen can reach the silks. Compare the length of time the silks live on this ear with the time they live on an ear that is pollinated. Compare the length of the silks in the two cases. In the fall bring to school the ear that had the sack tied over it. Explain the results shown.

EXPERIMENT NO. 23.

JUDGING CORN BY MEANS OF THE SCORE CARD.

Discussion. To compare ears of corn as to their value for seed purposes judge corn by the aid of the following points:

Apparatus. Tape measure 12 inches long; ten ears of corn as nearly uniform as possible: and a small magnifier, if one is to be had.

Procedure. It would be impossible to give all of the standards by which corn is judged, so a sample score card that embraces the most important points in the judging of dent corn is given below These points are:

(1) *Uniformity of Exhibit.* All the ears in the exhibit should be similar in size, shape of kernels, and other characteristics. In other words, the ten ears should look alike for this indicates that they are of the same variety.

(2) *Shape of Ears.* In general classes the shape of the ear should be cylindrical or nearly so; it should be full and strong in the middle portion, and the circumference, measured three inches from the butt of the ear, should be three-fourths of the length. The rows of kernels should be straight and not less than 16 nor more than 22 in number.

(3) *Length of Ears.* The length of the ear depends upon the section of the state in which the corn is grown. Refer to State Corn Growers' Association, or to the Agricultural College for length of ears in your section. For deficiencies in length cut at the rate of one point for each inch.

(4) *Color of Grain and Cob.* The color of corn should be true to variety and even in shade. White corn should have white cobs and yellow corn red cobs, except in special varieties where another color is found throughout. For each mixed kernel on an ear a cut of one-fifth point should be made.

(5) *Tips of Ears.* The form of the tip should be regular and not too tapering. It should be well covered with kernels of uniform size and shape.

(6) *Butts of Ears.* The rows of kernels should extend over the end of the cob in regular order without any enlargement or expansion, and should leave a depression where the shank is removed.

(7) *Kernel.* (a) Shape:—The tips of the kernels should be full and strong. The crowns should not be much rounded, and the kernels should fit snugly on the cob. See Experiment No. 31.

(b) Indentation:—The crowns of the kernels should be rather deeply dented but not pinched or chaffy.

(c) Uniformity:—The kernels should be alike in all the ears of the exhibit.

(8) *Seed Condition.* The ears should be well matured, firm and sound. The germs should be large, bright and vigorous looking.

(9) *Proportion of Corn to Cob.* See Experiment No. 24.

NAME OF VARIETY ______________________ TABLE NO. ____

NAME OF SCORER ______________________ SAMPLE NO. ____

EAR NUMBER		1	2	3	4	5	6	7	8	9	10
UNIFORMITY OF EXHIBIT	10										
SHAPE OF EARS	10										
LENGTH OF EARS	10										
COLOR OF GRAIN AND COB	10										
TIPS OF EARS	5										
BUTTS OF EARS	5										
KERNEL (1) SHAPE	10										
(2) INDENTATION	5										
(3) UNIFORMITY	10										
SEED CONDITION	15										
PROPORTION OF GRAIN TO COB	10										
TOTAL SCORE	100										

The above score card and rules may be made the basis of several hours work. Have students bring ten ears of corn from home and exhibit the same. Have them examine each ear and discuss how well it fits the standard shown in the score card. Finally have each pupil score ten ears using the blank above. The ten spaces on the score card give the student an opportunity to score either ten ears or ten exhibits.

After scoring the exhibits have each pupil pick out the best ear in his ten-ear exhibit and enter it for the best single ear. The teacher might award a prize or ribbon for the best ear. This makes an interesting contest with practical and profitable work.

EXPERIMENT NO. 24.

PROPORTION OF CORN TO COB.

Discussion. To be able to determine the proportion of corn to cob, in an ear of corn, rapidly and accurately is a very valuable acquirement, for any one who must handle corn. However, this can only be accomplished by repeated guesses corrected each time by actual weighing of the ear.

The opposite form will furnish very valuable work along this line. We grow corn neither for beauty nor for pleasure. The only object in growing corn is to produce an ear that contains as much grain and as little cob as possible. The general standard of corn at present is eighty-six per cent, that is, of an ear of corn 86 per cent of the entire weight should be corn. Variety standards, of course, vary from this amount. Name some varieties of corn and the per cent of corn which they should shell.

In the score card given on a previous page, for each per cent the corn scores under 86 per cent mark the exhibit down two points. In scoring exhibits, we are not usually permitted to shell any of the ears to determine this point. Since this is the only way it can be done accurately we must learn to estimate the proportion of corn to cob very closely. To do this experiment with ears of corn which may be shelled because they are of no special value.

Apparatus. Balances; ears of corn; sheet of heavy wrapping paper and pins.

Procedure. First, estimate the proportion of corn to cob of a single ear. To do this, remember that an ear of corn with long kernels, heavy for its size, and with the rows of kernels close together, will usually shell 86 per cent or better of corn. In the place marked "Estimated Proportion of Corn to Cob," on the opposite blank, put down the percentage of corn which you think a certain ear will shell.

In the second blank space labeled, "Proportion of Corn to Cob by Volume," place the amount which you estimate an ear will shell, using the following mechanical method as a basis for your estimate. This method is excellent when no balances can be obtained. Take the ear of corn to be scored and wrap it tightly in a piece of paper large enough to entirely enclose the ear. Twist the ends of the paper at the butt and tip and pin along the sides so that it will not come unwrapped. Tear off the paper around the butt of the ear enough that the edge of the paper stands just even with the butt of the ear. Then slip the ear out of the wrapping without changing the size or shape of the paper. Shell the ear and pour the corn back into the paper from which the ear was removed. If the shelled corn fills the space which was previously occupied by the entire ear, the ear tests 86 per cent or better. Is there as much chance for error by this method as by the former?

The third method is the only accurate method. Weigh the shelled corn and weigh the cob; add the two and divide the weight of the corn by the total weight, which will give the percentage the weight of the shelled corn is of the entire weight. By estimating the proportion of corn to cob of many ears and testing the results the student should become very accurate. When the blanks on the opposite page are filled, compare columns A and C and place the difference between them in Column D.

NAME OF VARIETY ______________________ TABLE NO. ______

NAME OF SCORER ______________________ SAMPLE NO. ______

PROPORTION OF CORN TO COB

EAR NUMBER	1	2	3	4	5	6	7	8	9	10
A ESTIMATED PROPORTION										
B PROPORTION BY VOLUME										
C PROPORTION BY WEIGHT										
D DIFFERENCE BETWEEN A & C										

PROPORTION OF CORN TO COB

EAR NUMBER	1	2	3	4	5	6	7	8	9	10
A ESTIMATED PROPORTION										
B PROPORTION BY VOLUME										
C PROPORTION BY WEIGHT										
D DIFFERENCE BETWEEN A & B										

EXPERIMENT NO. 25.

SELECTING SEED CORN IN THE FIELD.

Discussion. The crop of corn is largely determined by the care used in selecting seed the preceding fall. In order to get the best seed it should be selected from standing stalks, so that all characteristics can be noted. To learn to select seed corn intelligently is the object of this experiment.

Apparatus. Either a bag that can be swung over the shoulder like a game sack, or a basket; a field of mature corn, and a tape measure.

Procedure. Each student should go to the field and select from ten to twenty ears of seed corn, noting carefully the points governing selection given here.

(1) *Stalk.* In selecting seed corn, notice first the stalk. Stalks from which seed corn is selected should have a large number of leaves, should be strong, stocky, medium sized and well matured.

(2) *Position of the Ear.* The ear should be attached to the stalk at a point from three to four feet from the ground. The shank (that part which fastens the ear to the stalk) should be neither too long nor too large. It should be just long enough to permit the ear of corn to hang point downward. An ear of corn that stands upright when mature is usually not considered desirable, for the reason that it permits moisture to enter the ear and damage it. Also, such an ear, as a rule, is light and chaffy.

(3) *Shape of the Ear.* Note carefully the shape of the ear. The length of the ear depends largely upon the section of the state in which it is grown and the variety of the corn. The circumference of the ear should be three-fourths of the length. The kernels should be regular, well shaped, deeply dented, and should extend well over the tip and butt of the ear. Avoid kernels that are chaffy, but as a general rule, select ears for seed that are a little more deeply dented than those you expect to harvest.

(4) *Purity.* The kernels should show a purity of color. Do not select seed ears that show variation from the color desired. Variation in color shows immaturity, crossing of varieties, or disease.

After selecting your corn take it to the school building and lay it on a table, with the ears side by side. Pick out the best ten ears from the lot you have selected in the field and enter them in a contest with the other pupils for the best ten ears of corn selected. After the exhibits are scored according to Experiment No. 23, and the best ten ears in the entire lot are selected, answer the following questions:

What is the value of having the height of the ear on the stalk between three and four feet? Why do we desire the ear to have rather a small shank? If an ear of corn is nine inches long, what should be its circumference? What is chaffy corn? What is meant by Purity of Color? Why is it important? What is the value of a large number of leaves on a plant? Why do we select seed corn from the stalk rather than from the crib? If the moist corn were left in the field how would an early frost or freeze affect its germinating power when planted the following spring? Should seed corn be allowed to freeze before it is thoroughly dry? Is it ever advisable to let seed corn freeze if it can be avoided? Explain.

EXPERIMENT NO. 26.

A HOME PROJECT IN SEED CORN PRODUCTION.

Discussion. On a farm where the seed is selected from the field much improvement may be made in the seed by detasseling stalks in that part of the field where the seed is to be selected. If the ears of corn are pollinated by pollen from healthy stalks of the same type to the exclusion of all other pollen, the ears will be of better productive power than if pollinated at random. To secure this result we must remove the tassels from all barren or defective stalks before they ripen pollen and we must remove the tassels on all stalks from which we expect to secure seed so they will not, by any chance, be self pollinated.

Apparatus. A field of corn before the tassels begin to appear.

Procedure. Go into the center of the corn field and there mark off a number of rows for your seed plot. This should be done before the tassels begin to appear on the corn stalks. The advantage of selecting parts of rows in the center of the field is that such rows do not receive any large amount of pollen from neighboring corn fields.

As soon as the tassels begin to appear remove all tassels from every other row in the part of the field you have selected for your seed plot. This prevents self pollination of the seed ears. The tassels should be removed every day as they appear so they will not have time to ripen pollen. Also, detassel the barren plants and defective stalks in the other rows so they cannot scatter pollen. This should be done each day as long as tassels put forth.

To detassel a stalk of corn simply pull over the stalk, grasp the tassel and pull it out. It will break off at the first joint which will not in any way injure the stalk or the production of corn. Do not cut off the tassel as this causes more of an injury to the stalk.

When the seed is mature select seed from the detasseled stalks in accordance with Exercise No. 25. This method will produce for you the best seed corn possible to obtain without purchasing high grade seed or maintaining a special corn breeding plot.

EXPERIMENT NO. 27.
GRADING SEED CORN.

Discussion. In grading corn most people have a screen with large oblong meshes, called a corn grader, through which the kernels are passed. This screen separates most of the ill shaped kernels but some remain. Examine the uniformity of both graded and ungraded grain.

Apparatus. Ears of corn to be graded and some corn that has been passed through a corn grader.

Procedure. Shell some ears of corn having medium sized kernels retaining only the body kernels. Take a pint of these kernels and by hand remove all the large, small, irregular, broken, diseased, and chaffy kernels. How many are rejected? Count the number of good kernels and figure the percentage that are good. Corn graded by hand will assure an even drop through the planter and give an even stand of corn. In a like manner examine corn that has been graded through the grader. If there is a corn planter that may be used test the accuracy of the drop by propping it up and turning the wheels by hand. Compare the drop of a planter using both graded and ungraded grain.

EXPERIMENT NO. 28.
WEIGHT PER BUSHEL OF DIFFERENT VARIETIES OF CORN.

Discussion. The percentage of corn to cob varies widely in different varieties of corn and Experiment No. 24 shows how to determine this percentage on basis of a single ear. However, since the percentage of corn to cob determines the weight per measured bushel, to a large degree, the best corn may be determined by weighing different samples. Sometimes a field of corn of a variety that has good deep kernels, small cobs, and well filled ears, will produce more actual corn than another field which looks better, but has large poorly filled cobs, and shallow kernels. A good way to find the best corn in the community in this respect is to perform the following experiment:

Apparatus. Access to the corn crib at home; a bushel basket; a pair of scales that will weigh 80 pounds or more.

Procedure. Selecting average ears, exactly a bushel of corn in the ear should be measured out, and weighed. This may be done at home. Measure out and weigh three different bushels, so that the test will be a fair average. Write each weight in the space provided on the opposite page and find the average of the three trials. As rapidly as other pupils bring in their answers, write their average results in the space provided. Write the variety of the corn wherever it is known, and if unknown, fill in the color, as white, yellow, etc.

Who in the community has corn that weighs most per measured bushel? Who has the corn that weighs the least? Examine ears of corn from each of these two cribs. What difference do yout notice? If possible determine the variety of each sample of corn. Name some varieties of corn that seem best suited to your community. Name as many additional varieties as you can. Count the number of ears of corn in a measured bushel. Count the number of ears in a bushel by weight. How much do the two vary?

WEIGHT PER BUSHEL OF DIFFERENT VARIETIES OF CORN					
PUPIL'S NAME	WEIGHT PER BUSHEL			AVERAGE WEIGHT PER BUSHEL	VARIETY
	1ST. TRIAL	2ND. TRIAL	3RD. TRIAL		

EXPERIMENT NO. 29.

STORING SEED CORN.

Discussion. The subject of corn would be incomplete unless mention were made of the methods of storing seed corn. When seed corn is gathered in the fall it often contains as much as 45 per cent of moisture, while air dry corn contains on an average, only about 12 per cent of moisture. If corn is frozen when it contains a large amount of water the expansion of the water ruptures the cell walls and the vitality of the seed is greatly impaired and may be even destroyed.

Corn should be stored in a dry, well ventilated place, where the temperature does not become too low. Moderate freezing does not hurt seed corn if it is thoroughly dry.

Apparatus. Corn Kernels.

Procedure. Weigh out a handful of dry corn kernels. Soak them in water until they have increased in weight about thirty-five per cent. Immediately expose them to freezing temperature. Later plant the kernels and compare their germinating power with kernels that have not been frozen. The frozen kernels correspond closely to kernels on the ears selected from the field after there has been freezing weather. Discuss different methods of storing seed corn, and kind of corn racks used in your community, such as the corn tree, string method, patent hangers, etc.

EXPERIMENT NO. 30.

TO DETERMINE THE SHRINKAGE OF CORN.

(Adapted from the State Course of Study of Indiana.)

Discussion. There is a loss in the weight of corn after husking because of the fact that at husking time the corn contains a large amount of water which soon evaporates. Not all of the moisture evaporates, as much as twelve per cent remaining in the corn under the best average conditions. The amount of water in corn that evaporates varies with the kind of corn, the time of husking, and the kind of season. If the corn is husked before it is fully mature, it will contain more water than if matured. If the weather is dry after the corn ripens, it will contain less water than if it is wet. Also, the drier the corn is when husked the better it will keep in the crib. Too much moisture causes corn to mould and for this reason it must not be cribbed too early in the fall.

Apparatus. Ears of corn from the field; a pair of balances, and a tape measure.

Procedure. Take three ears of new corn from the field and label them numbers, 1, 2 and 3 respectively. Measure the length of each ear and put down the results in the proper spaces provided on the opposite page. Measure the circumference of each ear three inches from the butt and place the results on the opposite page. Also, weigh each ear and record results in the spaces indicated.

Hang up the ears and let them dry for two weeks and repeat the experiment as above. Record the results. In a like manner repeat the experiment two weeks later.

What is the entire amount of shrinkage in the length of each ear? What is the entire amount of shrinkage in the circumference of each ear? In the weight? Counting 100 ears to the bushel, how many pounds would a bushel of corn shrink in drying during the first six weeks? How many pounds of ear corn in a bushel? Find out the price of corn early in the fall, at the beginning of your experiment, and later in the year, when the experiment is completed. If you consider the shrinkage, is there much difference in price? If time is to be had, it would be well to continue this experiment throughout the entire winter, using ears from the crib and returning them to the crib after each examination. In this manner you would perform your experiment under actual field conditions, and would not have the ears subjected to artificial temperature.

SHRINKAGE OF CORN

	EAR NO.1	EAR NO.2	EAR NO.3	AVERAGE	% OF SHRINKAGE	DATE OF EXAMINATION	VARIETY
LENGTH							
LENGTH							
LENGTH							
CIRCUMFERENCE							
CIRCUMFERENCE							
CIRCUMFERENCE							
WEIGHT							
WEIGHT							
WEIGHT							

EXPERIMENT NO. 31.

THE SIZE AND SHAPE OF THE CORN KERNEL.

Discussion. Usually tips and butts of seed corn have been discarded for the reason that they did not drop evenly through the planter. Lately there has been devised improved planters that drop evenly regardless of the size or shape of the kernels, and it is now becoming popular to plant all of the kernels. While some people advocate this principle there is a strong probability that such a practice is not the best method.

When an ear of corn begins to put out silks, the silks that receive pollen first are the ones that are attached to the butt kernels. The ones receiving pollen last are the ones that pass to the tip kernels. The butt kernels and the tip kernels are the ones most likely to be fertilized by abnormal plants; the dwarfed early maturing plants fertilizing the butt kernels, and the late weak plants fertilizing the tip kernels. For this reason alone, the butt and tip kernels should always be discarded.

It has already been shown that the little plantlet must get its food for the first few days from the supply stored in the seed. If the seed is small, as tip kernels usually are, the little plantlet does not get enough food to give it a good start and, therefore, it becomes stunted. A plant that has once been stunted will not retain its vigor. Therefore, we should see to it that large kernels are planted in order to furnish a maximum amount of food to the little plantlet. To test kernels for size and uniformity use the following simple method:

Apparatus. A small piece of board or shingle one-sixth of an inch thick; ears of dent corn to be tested; a sharp knife and a few small nails.

Procedure. Cut a notch in the side of the board five-sixteenths of an inch wide and three-quarters of an inch long. Make it the shape of the notch shown in the drawing (Figure No. 12). Fasten this piece of board to the smooth surface of another board and five-eighths of an inch from the top of the notch draw a heavy line as shown in Figure No. 12. The average shape of a kernel should be one-sixth of an inch thick, five-sixteenths of an inch wide, and five-eighths of an inch long. If a kernel is placed in this notch it is easy to tell how near it comes to being the correct size. Some kernels will be too thick while others will be too broad and short.

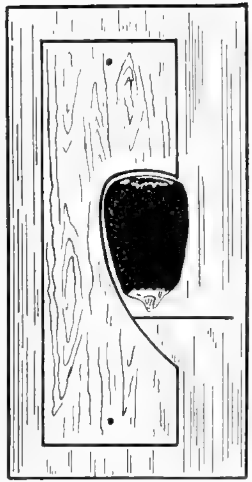


Figure No. 12.

Device for Testing Shape of Kernels.

A few will be too long. A kernel may reach below the black line showing excess length and still be an excellent kernel. If it is shaped properly otherwise and reaches below this line, it is usually an exceptionally good kernel, for the reason that kernels of this kind shell out a large percentage of corn. Of course the proper depth of kernel must depend upon the length of the growing season and the fertility of the soil. A general rule covering the length of a kernel is, that the length of the kernel should be one-half the diameter of the cob. Any kernels of dent corn that are shorter than the required dimensions or thinner than the test board that you have made, should not be kept for seed. With this devise, test kernels from a number of ears of corn. Test tip, butt, and body kernels from each ear. Which part of an ear shows the most uniformity in size and shape of kernels. Write a discussion on the disadvantages of planting poorly shaped kernels.

EXPERIMENT NO. 32.

FIELD EXERCISE: DETERMINING THE VALUE OF TIP AND BUTT KERNELS.

Discussion. Students may experiment in a practical scientific manner, to determine the value of tip and butt kernels as follows:

Apparatus. Plot of ground in the spring or boxes of soil indoors, and ears of corn to test.

Procedure. Plant the tip kernels of corn in one row, the body kernels in the next row and the butt kernels in the third row. Give them the same treatment and compare results. Which row shows the best germination? Which row gets the best start? Which makes the poorest growth? Which row has the most barren stalks? Which the least? What conclusion do you draw from this experiment? If no plot of ground is available the experiment may be performed, as far as germination and early growth is concerned, indoors in boxes of soil. The experiment cannot be judged so accurately by this method.

EXPERIMENT NO. 33.

THE WHEAT PLANT.

Discussion. Wheat ranks second among the most valuable crops grown in the United States, corn ranking first. Its importance is due to the fact that wheat is used very largely for human food and because it adapts itself to such wide ranges of climate. Wheat not only grows in the warm and cool regions, but in both the wet and dry climates as well.

Wheat requires a firm seed bed since its permanent roots are put forth near the surface of the ground and since it requires considerable noisture for germination. A firm seed bed supplies the little seedlings with more moisture than a loose one. Can you tell why? We hear some people say that the roots of wheat will grow down farther if the seed bed is loose, and sometimes farmers sow their wheat deep, expecting the roots of the wheat to penetrate deeper into the soil where they can get more moisture and food. The farmers' plans concerning this do not prove to be correct and the proof of the error may be shown by the following experiment:

Apparatus. Seeds of wheat; a box of clean fine soil, and a warm room.

Procedure. Sow kernels of wheat one-half inch and two inches deep respectively in a firm seed bed. After plants are well up, carefully dig one of them that has been seeded one-half inch deep and one that has been seeded two inches deep. Compare them and make sketches to show any differences that may exist. About a week later dig another of each of the plants. Wash the roots carefully and make drawings to show any differences that may exist. Note especially the roots of the plants. Do you find the three temporary roots that were first put forth? The temporary roots and the permanent roots should put forth at about the same place if the seed has been planted at the proper depth. Are they at the same place on the plants seeded one-half inch deep? On the ones seeded two inches deep? Will deep seding place the permanent roots any deeper than shallow seeding?

Let a few of the remainder of the wheat plants grow for some time and compare the ones sown deep with the ones sown shallow. Watch them stool, or tiller as it is called. Which will tiller more, wheat seeded thick or wheat seeded thin? Why? How much seed is sown per acre on the farms in your community? How is it usually seeded? What is meant by spring wheat? What is meant by fall wheat?

The average yield of wheat for the United States is 14 bushels per acre. Is this more or less than the average yield in your community? Are fertilizers being used for wheat on the fields of your community? If so, do they give good results?

If possible you should perform this experiment on the school plot, for out of door conditions will give you the most reliable results. This experiment may be performed, out of doors, either in the fall or in the spring. In any event plant the wheat on a firm seed bed.

EXPERIMENT NO. 34.

A STUDY OF THE HEAD OF WHEAT.

Discussion. Rapid improvement has been made in wheat by the selection of wheat plants having only desirable characteristics. The yield has been materially increased by selecting heads of wheat containing a large number of kernels. Also, a great number of varieties of wheat have been evolved by selecting for certain characteristics in the type. Thus, we have varieties of wheat that are especially resistant to rust, others that are adapted to dry climate, etc. The student should become familiar with the wheat head in order to select wheat intelligently.

The head of wheat is called a *spike.* The central part of the head to which the kernels are attached is called the *rachis.* One bunch of kernels complete with its little stem is called a *spikelet.* The wheat kernel when it first begins to develop with its covering or hulls is called the wheat *flower.* The hulls or coverings around the kernel are called the *palea* and *glumes.* The glumes are the larger and the inner glume often has a *beard* or *awn* of more or less prominence extending from it.

Apparatus. Heads of wheat.

Procedure. Study the head of wheat, noticing the following points: Observe that the grains are arranged on either side of the stem. A single group of grains is called a spikelet. How many spikelets on the head being examined? To what are they attached? How are they arranged? How many grains in a spikelet? Is the number uniform? Are the spikelets all filled? Find, if possible, a spikelet with three grains; with four grains; with five grains. Remove the coverings from a single grain. How many coverings are there? What are they called? How is the grain attached to the rachis?

Pull up an entire plant. How many stalks in the bunch? Does the number vary with the different bunches? Estimate the number of grains that may be produced from a single seed.

EXPERIMENT NO. 35.

WHEAT FLOUR.

Discussion. There are many different grades of flour, all depending upon the quality of wheat from which the flour is made, the method of milling, etc. Perform the following exercise to compare different brands of flour.

Apparatus. Two brands of flour, a cheap flour and a high grade flour. (A teacupful of flour of each kind will be sufficient for five pupils.)

Procedure. First moisten the high grade flour with enough water to make dough. Work the dough thoroughly between the fingers and then wash the dough until all the white starch is washed out. You will then have a sticky mass of protein. In wheat this protein is called "gluten."

In a like manner, wash the starch from an equal amount of low grade flour. Compare the two samples of gluten as to color. Compare the two as to the distance they will stretch. This is the important test as the best flour is the one that has the largest quantity and the most flexible gluten. Why does the flour whose gluten stretches the more make lighter bread than the other? Why does not corn flour make as light bread as wheat flour? If preferred the gluten may be removed from wheat by chewing the kernels. In a little while, the starch and hull or bran will be carried away by the saliva and "wheat chewing gum," or gluten will remain. Compare different types of wheat by this method. Try the same thing upon some other grains. Explain why wheat is used so much more than other cereals for bread. Why cannot we make light bread from potato flour?

EXPERIMENT NO. 36.

THE STOOLING OF THE WHEAT PLANT.

Discussion. Wheat, like other cereals, has the characteristic of throwing out side shoots or stalks. This process is called stooling or tillering. The number of stalks varies with the season, type of seed, etc. There are usually at least six, but there may be from one to fifty shoots coming from one seed. As a rule, the more favorable the conditions for plant growth and the thinner the wheat is on the ground, the more it tillers. When the weather is cool and moist, we find wheat sending out many shoots. It is not advisable to sow wheat too thin for, although it may stool more it will usually yield less than a field where the stooling is not so marked.

Apparatus. A number of wheat plants gathered from the field late in the fall. Obtain the entire plant if possible.

Procedure. Make a drawing to show an entire plant. Count the number of shoots coming from one seed. Count the number from five average plants. Figure the average number of shoots per plant for the field. Is the number more or less than six? When does wheat do most of its stooling? Is the stooling habit of wheat a valuable characteristic? Suppose a number of wheat plants in the field are winter killed, what will the other plants do to make up this loss? Make a list of the plants which have the characteristic of stooling. For which do you sow the most seed, a crop of wheat or a crop of oats? Why?

EXPERIMENT NO. 37.

PREPARING THE SEED BED FOR WINTER WHEAT.

Discussion. In the growing of wheat the seed bed is one of the most important factors, yet much over half of the wheat sown is planted on poor seed beds. When it is taken into consideration that the farmer often spends as much, or more, time and money in preparing a poor seed bed than it would take to prepare a good one, it is strange that this subject is not given more consideration. An ideal seed bed for wheat is a firm, well compacted soil, containing a good supply of moisture and available plant food. Such a seed bed cannot be prepared the week before seeding time and it is only possible to prepare an ideal seed bed by beginning early in the summer.

Figure No. 14.
A Proper Deep and Shallow B Improper Seeded Kernels.

In regions where rainfall is scant it is well to practice summer fallow at regular intervals followed by medium early plowing. Where the rainfall is more abundant the frequency with which it is necessary to practice summer fallow is less. Where there is sufficient rainfall each year for the needs of the crop early plowing may be a sufficient method of conserving the moisture. In practically all wheat regions it is safe to say that early plowing is the safe procedure for large wheat yields. In many instances plowing is unnecessary, and the above statement refers only to those fields that are to be plowed at some time during the season for the wheat crop. Where the soil is to be plowed, early disking followed by rather early plowing is an excellent practice, but it is never advisable to stir the seed bed much just before seeding time.

Apparatus. Fields of wheat, in the community, that may be studied.

Procedure. In the average community much more variation will be found in the manner of preparing seed beds for wheat than is commonly supposed. Carefully tabulate the methods of preparing for the seeding of wheat as they are carried out by a number of farmers in the community. Then record all results and outline the most profitable method judging from the actual results observed. Note whether the land is listed or disked; the date the soil is plowed and the depth of the plowing. Inquire as to the rotation that has been practiced on the various fields. If a field can be found where the soil has been cropped to wheat continuously for a number of years observe the results of such a practice.

Unless the ground is very dry it is not a good practice to seed wheat deeply. As a rule one inch is deep enough for the seed. If the seed is planted too deep Figure 14B shows what will happen. This means the loss of about 27 days to the plant in adjusting itself to the conditions imposed. The plant number 14A was properly seeded while the one, number 14B was not. Dig some wheat plants in the field about a month after planting and compare them with the two figures shown. Do you find evidence of plants being improperly seeded?

The permanent roots in Figure 14B grew near the surface above the temporary roots. The little plantlet had to exist for several days without food while these new roots were forming. The food in the seed was all consumed in the plant's heroic efforts to get

above the surface of the ground and the plant had to go through a period of semi-starvation until the permanent roots were established. Of course, when the soil is very dry it may be necessary tto seed deeper in order to have moisture enough for proper germination, but in ordinary seasons the farmer seeds wheat too deep.

Another test of a proper seed bed is the following: Wheat on a proper seed bed refuses to be pulled up; it either breaks off or brings the soil with it. When wheat pulls up easily, leaving the soil, you can be sure that the seed was planted on the wrong kind of a seed bed. Obtain bulletins from your State Agricultural Department relative to the seeding of wheat. Compare the maxims there set forth with the actual results determined by your personal observations.

This experiment cannot be performed in a day but should furnish interesting and valuable work throughout an entire year. Blanks should be prepared for gathering this data and the farmers should be encouraged to contribute details. It should be necessary for the pupils to collect and record accurately all the information and deduct conclusions at the close of the experiment.

EXPERIMENT NO. 38.

A STUDY OF THE OAT HEAD.

Discussion. Oats are among the most important crops commercially and we should become familiar with the oat head and the parts that compose it. The head of oats complete is called the *panicle*. It is made up of several parts, of which the kernel is the most important. The kernels are attached to little stems called spikelets. Usually on one spikelet there are two kernels, the upper kernel being the larger; sometimes its cover almost envelopes the lower kernel. The oats kernel has a covering that sticks to the kernel very tightly, remaining after the grain is threshed. This covering is called the *flowering glume*. In some varieties we find a long spine or beard that grows out from the flowering glume. Where this occurs we say the oats are *bearded oats*.

Apparatus. Heads of oats; oats that have been through the fanning mill, and some oats from a bin.

Procedure. Compare two kernels that grew on the same spikelet. Is there any difference in size? Do the oats on the head being examined have long beards? Is the beard a part of the kernel? Locate the flowering glume. What is the standard weight of a bushel of oats in your State.? Per measured volume which is the heavier, oats or wheat? Why? Compare oats that have been through the fanning mill with those that have come from the bin. Do you notice any difference in size? What is the advantage of sowing oats that have been through the fanning mill?

Make a drawing to show the head, spikelet, kernel, stem, and beard. On basis of color how many classes of oats do we have? Inquire at the elevator concerning the grading of oats. Inquire concerning the prices. Obtain some chaff that comes from the fanning mill when oats are fanned and examine it. Make a list of different kinds of foreign materials separated from the oats by the fanning mill.

EXPERIMENT NO. 39.

PURITY OF OATS.

Discussion. The one seed impurity most often found in oats is "Chess." Chess is commonly referred to as "Cheat." This plant, which somewhat resembles oats, is grown in places for hay. In localities where wheat and oats are common chess is a very bothersome weed. On account of its resemblance to oats it is difficult to detect the presence of the seed. A flowering glume of the oats kernel and a kernel of chess are almost indistinguishable.

Apparatus. Samples of oats obtained from several sources, and a tripod magnifier.

Procedure. Take equal weights of each sample and determine the seed purity. Find seeds of chess and describe them. How are they different from oats? What is the best way to remove them from seed oats? Examine a chess seed under the magnifier. Does it have an embryo? Plant some chess seed. Do they grow? Will wheat produce chess? Are there people in your community who believe that it will? Fill in the blank form below.

EXAMINATION OF OATS FOR PURITY

SAMPLE NO.	PERCENT OF GOOD SEED	PERCENT OF WEED SEED	PERCENT OF TRASH
NO. 1			
NO. 2			
NO. 3			
NO. 4			

EXPERIMENT NO. 40.

A STUDY OF THE ROOT SYSTEM OF PLANTS.

Discussion. It is necessary to understand the nature of the roots of a plant when cultivating it. All the roots upon the plant make up the root system, and all root systems are divided into two classes. These two classes of roots are:

(1) Tap Roots:—A central root with smaller roots branching from it. Examples of tap rooted plants are radishes, beets, etc.

(2) Fibrous Roots:—A system of roots nearly all the same size without any main central axis, or root. Wheat is an example example.

Tap rooted plants require a deep soil and will permit close and deep cultivation, while fibrous rooted plants require shallow cultivation, and are often injured by deep cultivation during the growing season.

Apparatus. A mature corn plant carefully dug up leaving as many of the roots on it as possible, and a clover plant with its root system. Obtain as many more plants with their root systems as you can. If mature plants cannot be obtained successfully, grow young plants until they are large enough to determine their root systems.

Procedure. Determine whether the root system of the corn plant has a tap root, or if it is fibrous in its nature. Make a drawing to show the nature of the roots. Decide whether clover is a tap rooted or a fibrous rooted plant. Make a drawing to show this. What kind of cultivation should be practiced in cultivating corn? In cultivating clover? Do you think that the average farmer in your community plows his corn at the proper depth? How deep do you think that corn should be cultivated?

Note the roots that start above the ground in the corn plant. What are these roots called? Many people get the idea from this name that they only hold up the plants. They do more than this and in addition to supporting the plant they gather food and moisture. Get your father to leave a row of corn in the field, that is not too weedy, without any cultivation after the corn is planted. Note the results in the amount of corn produced in this row as compared with other rows that have been cultivated. This experiment might be elaborated to cover rows of corn cultivated one, two, three, and four or more times respectively and rows cultivated deep and shallow. Such an experiment should lead to some rather valuable conclusions which would no doubt lead to further experiments. Write a discussion on the proper cultivation of corn.

EXPERIMENT NO. 41.

STRUCTURE OF THE CORN PLANT.

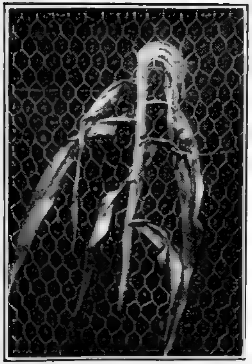


Figure No. 16.
A Recessive Corn Flower Containing Kernels of Primitive Corn.

Discussion. A plant which makes such wonderful growth as the corn plant is worthy of careful study. The method of growth of this plant and its size makes it necessary that a method be provided by nature for obtaining food substance in abundance and a method of manufacturing this food rapidly. The large seed is capable of giving the plant a vigorous start and the elaborate and extensive root system is designed to furnish a large amount of moisture. Also, the large leaf surface is capable of converting material into plant food very rapidly.

Since so large a growth of plant material is made in such a short time the structure of the stalk must be unusually strong to support the mature plant. The height of corn may vary from 18 inches in Tom Thumb pop corn, to 30 feet or more in the large varieties grown in the West Indies. Stalks 22¼ feet long have been reported from Tennessee. Corn plants have been known to make a growth of 5 inches in a single day. About 85 per cent of the root system which furnishes this great amount of food is found in the first four inches of the soil; a larger percentage than this being present near the surface during the first half of the life of the plant. Examine a complete plant with reference to its structure, as follows:

Apparatus. A mature stalk of corn complete with roots attached.

Procedure. Examine the shape of the corn stalk. Is it round? Note the joints. The joints are called *nodes* and the spaces between the joints, *internodes.* Note how the leaves are spaced on the stalk. How are they attached to the stalk? Make a drawing to show this. Note that the outer edge of the corn leaf is wrinkled due to the fact that the edges of the leaf grow faster than the center. Can you see any advantage in this? It looks as if a strong wind might break the large corn leaves. Take hold of a leaf and pull it around as if to break it off. Where does it give before breaking? This part of the leaf that surrounds the stalk just above the joint is called the *sheath.* How is it provided to prevent rain and dirt from getting between it and the stalks?

Cut a stalk of corn in two. Note the little fibres throughout the white pithy part of the stalk. They are called the *fibro-vascular bundles,* and carry the food to all parts of the plant. Is a corn stalk strong? Try breaking one. Where does it break, at a node or at an internode? Do you know of any other plant that makes so large a growth in the same length of time? If so compare the two. Do you know of any plant that produces so much grain in such a short time? If you have not already done so be sure to examine the flowers of the corn plant.

EXPERIMENT NO. 42.

SILAGE.

Discussion. An appreciation of the full value of silage as compared to fodder crops induces the preserving of the corn plant in its green or succulent state as a food for the farm animals. First, let us distinguish between silage and fodder. Any roughage or hay crop that is cured before being stored is usually referred to as fodder, while if a crop is stored and kept in its green state it is called silage. Thus we may have silage made from many different crops. Experience has shown us that corn makes the best all around silage of any of our common crops. However, corn silage is often mixed with other crops and is sometimes helped by the mixing. Alfalfa is often used in the silo with corn; cowpeas, soy beans, and the sorghums have also been used in similar mixtures.

Silage is relished very much by farm animals and is more digestible than the same crop would be after having been cured. Silage is prepared by storing the green crop in specially constructed buildings with air-tight sides. Round silos are the best form and they are about the only kind in use at the present time. Formerly, silos were square.

Green crops are usually placed in the silo by running them through a silage cutter, a machine which cuts the crop into small pieces and either blows or carries the entire crop into the silo. Once in the silo the crop soon settles into a very compact mass and the top spoils. The spoiled layer on top, together with the pressure and gases formed, keeps the air from the remainder, and in this manner the large silo is sealed much like a can of fruit.

Apparatus. Any silo that you can visit. If it is impossible to visit a silo, obtain a small quantity of silage and become familiar with its nature. Bring to school samples of silage obtained from the silos of your community.

Procedure. Visit any farm which has a silo and fill in the blanks on the opposite page. Visit one silo when they are filling it, if possible. The more silos you visit and study carefully the more your knowledge of this new and wonderful way of preserving crops will grow. Note difference in the samples brought to school and explain reasons for the difference.

Many questions besides those given on the opposite page will suggest themselves. Write five questions concerning the silo. Write the answers and discuss them in class.

Name the crop or crops used for silage in the silo which you have visited..............................

Give the date on which the silo was filled..

What is the capacity in tons of the silo visited?...

Give the number of acres of the crop used that were required to fill it....................................

Describe the odor, taste and color of silage...

What has given it this peculiar taste?....... ....

What animals eat silage?..

What animals apparently relish it most?...

Name as many different materials as you can from which silage is made........... ....

What does the farmer who owns the silo which you visited think of silage as a feed?.................

....

How do you feel towards letting the corn stalks go to waste, after going to all the trouble of growing them? ....

In a corn crop which is the larger part of the crop, the corn or the plants? ....

How much per ton does it cost to fill a silo?...

Describe a silage cutter...

Why should silage be tramped as it goes into the silo? ....

Do horses relish silage? .... Is it good for them? ....

Figure No. 17.
Silo.

NOTE The last question is usually cause for a difference of opinion and a discussion of the same should prove of value in your class Have the pupils bring to class records of their own observation, in as many cases as possible.

A STUDY OF COWPEAS.—EXPERIMENT NO. 43.

Discussion. Cowpea hay makes a nutritious feed for live stock and contains a great amount of protein. The cowpea seed make the most nutritious feed, but at present they are more valuable for seed than they are for feed. Cowpeas shatter badly when harvested and are easily cracked and broken in thrashing. Seed which you purchase usually contains a large per cent of broken and cracked kernels, and these are of no value for seed. In selecting seed, get a variety that will mature in your locality, for some varieties are frosted before they can mature if the growing season is short. Also select seed that has as few damaged kernels as possible. Score cowpeas as follows:

Apparatus. Different types of cowpeas; a pair of scales, and a flower pot filled with soil.

Procedure. Weigh out four ounces of each sample of seed and examine for purity, condition and color. To examine for purity remove all of the seeds from the sample that do not appear to be true to type, (those that do not look like the majority of the ones in the sample) also, all foreign matter, which includes weed seed, trash and broken kernels. Figure the percentage of purity. To examine for condition pick out all damaged seed, either cracked, mouldy, diseased or immature. From this figure the percentage of good seed in the sample. To examine for color, separate the sample into two divisions; one that is true to the color of the variety under examination, the other containing all the seed that show any variation of color whatever. Which is the best sample? Discuss in class the methods of seeding cowpeas. Write a discussion on "Harvesting the Cowpea for Profit." Grow a cowpea plant in a flower pot and study its character and habits. Fill in the blank given below.

EXAMINATION OF THE COW PEA

SAMPLE	PURITY	CONDITION	COLOR	TOTAL
NO. 1				
NO. 2				
NO. 3				
NO. 4				

EXPERIMENT NO. 44.

A STUDY OF SOYBEANS.

Discussion. Both the cowpea and the soybean are destined to become very important crops in many sections of the United States where they have not previously been grown. The power of these plants to gather nitrogen from the air, (see figure, page 57) the large amount of organic matter they are capable of producing, the value of the seed crop, and their value as a forage crop are qualities which commend them in the highest degree. The cowpea is easily killed by frost and is not so hardy as the soybean. The cowpea is usually considered best for forage; the soybean is grown mostly for seed. The seed crop of either is considered profitable.

The value of the soybean for hay is comparable to alfalfa; the ordinary crop will yield about two tons per acre. As a pasture crop soybeans may be utilized by many animals, but they are especially good for hogs. An acre of soybeans will furnish pasture for eighteen or twenty hogs for an entire fall. Supplemented with a little corn, this crop gives remarkable results as a fattening medium. The same holds true of cowpeas. For a further discussion of these two very important leguminous crops see Bulletins published by the State and the United States Department of Agriculture.

Apparatus. Samples of different types of soybeans; scales, and a flower pot filled with soil.

Procedure. Proceed as under experiment number forty-three. Write a discussion on the soybean when the experiment is complete. Grow soybeans in a flower pot and observe. Fill in the blank given below.

EXAMINATION OF THE SOYBEAN

SAMPLE	PURITY	CONDITION	COLOR	TOTAL
NO. 1				
NO. 2				
NO. 3				
NO. 4				

EXPERIMENT NO. 45.

VARIETIES OF CLOVERS AND RELATED CROPS.

Discussion. In agriculture the term clover crops is sometimes applied to any of the leguminous plants that are used for forage. The close resemblance of the various clovers leads the average person to pay no attention to their distinguishing characteristics, with the result that few people are able to identify any of them by sight. In all there are about thirteen cultivated types of legumes in the United States, the most important of which are discussed below. You should learn to identify the ordinary ones by their common names at least.

Apparatus. As many different varieties of clover as you can obtain, and samples of the seed of the different varieties, obtained from your seed store, or some reliable source.

Procedure. Examine each variety of clover mentioned for the characteristics peculiar to that variety. Some of the characteristics are given below; add others as you find them. As explained in a previous experiment, mount each variety of clover on a cardboard and label. Write a discussion of the clovers. What is their chief value? Compare clover hay with other forage crops, such as timothy, corn, etc.

Medium Red Clover. This variety of clover is the most common of the clovers under cultivation in the Eastern part of the United States. It may be readily distinguished by the pale horse-shoe shaped spot usually present in the center of each leaf; by its numerous leaves and blossoms, and by its being smaller than the mammoth red clover, which is the only clover that it closely resembles. The flowers are rose-pink in color and produce small kidney shaped seed, varying in color from purple to yellow.

Mammoth Red Clover. Mammoth red clover is the largest variety of clover outside of the sweet clover, and resembles medium red clover except that it is larger. It is, in fact, a large variety of the medium red clover and, aside from the difference in size, about the only distinguishing feature is the fact that the leaves usually do not have a white spot. Also, it matures, as a rule, about two weeks later than the medium red clover. The seed of the two clovers are very nearly the same in appearance.

Alsike Clover. Alsike clover is distinguished from the red clovers by the absence of the white spot on the leaves, the smaller size, the different colored blossoms, and the low and branching nature of its growth. It is intermediate in appearance between the white and the red clover. By some people it is called Swedish Clover. Red clover lasts only two years, while alsike lasts from three to five years and even longer. The seed is smaller than the red clover seed and it produces a hardier plant.

White Clover. White clover is still smaller than the alsike clover, has unbranched flower stalks, and very numerous white or pinkish blossoms.

Crimson Clover. Crimson clover grows erect, with a stem that is very soft and hairy, and stools very freely. The heads are long cylindrical and cone shaped. The blossom is of a deep crimson color, hence the name.

Sweet Clover. Sweet clover is so named from its sweet agreeable odor. It is possibly the largest variety of the clovers, has few leaves and an inconspicuous blossom at maturity. It is very difficult to cure for hay, but is of value for this purpose, especially in arid climates. Its chief use is as a soil builder. It will grow where other clovers will not thrive, especially on clay hills and sandy stretches in the clover sections. It lives only two years and is similar in this respect to red clover.

Alfalfa. Alfalfa usually grows two or three feet tall and stools freely. The leaves are small and numerous, but they shatter badly when the plant is cured for hay. The flowers are usually of a bluish tint, but some varieties have yellow blossoms. It roots very deeply and produces from three to five cuttings a season, depending upon the length and nature of the season.

In identifying the clovers by the seed, the shape of the different varieties is the most distinguishing characteristic. Examine under the magnifying glass, seed of red clover, alsike, alfalfa, white clover, crimson clover, sweet clover, and any others you can obtain. Note the shapes characteristic of the seed of each kind. Note one kind that is heart-shaped. Which seeds may be described as triangular? Which ones are oval or egg-shaped? Name the kinds of seed that are kidney-shaped.

Under the magnifier, note the scar on the edge of the seeds. Explain the cause of the scar. Note the notch in which the scar is situated. Is the notch different in different seeds? Compare the seeds as to size. Color of the seeds helps to distinguish between the different kinds. Describe each kind as to color. Place all distinguishing characteristics in your notes.

After each kind of seed has been studied, the teacher will give you a mixture of seeds. Sort out the different kinds of seed and place them in separate piles. Identify each and have the teacher check your results. Place samples of each kind of seed in a bottle and label. Place the bottles in your Agricultural Exhibit.

FIELD EXERCISE.—CLOVERS.

- On the school garden, or in a corner of a field at home, sow a little square of each variety of clover that you can obtain. Examine it from time to time, noting the soil building properties, the rate of growth, the amount of growth, the cost and probable return of each. Feed some of each legume to the various animals. Classify legumes on basis of their feeding value to various animals; on basis of their value in your community.

EXPERIMENT NO. 46.

INOCULATION OF LEGUMES.

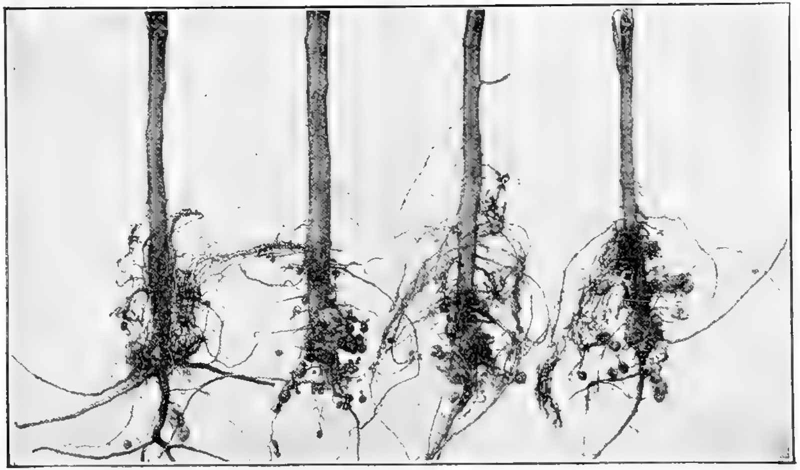


Figure No. 18.
Nodules on Roots of Soy Beans.

Discussion. Legumes differ from grasses in that they bear their seeds in pods, like peas or beans. Some of the most important legumes are the clovers, alfalfa, cowpeas, soybeans, vetches, etc. While all grasses add organic matter to a soil and tend to enrich it, if they are not removed, legumes add fertility in a special way, and are widely cultivated for that purpose.

Legumes are able to gather nitrogen which is one of the most important plant foods, from the soil air and deposit it in the soil. They accomplish this task by the aid of bacteria which live in "nodules" or knots on the roots of leguminous plants. In each nodule found on the roots of clover, alfalfa, etc., are millions of bacteria, each busily engaged in removing the nitrogen from the soil air, and changing it into a form that can be used by the growing plants. Of course, where there are no nodules present on the plant roots, due to lack of nitrogen gathering bacteria in the soil, the bacteria must be supplied if the crop is to do the soil the most possible good. Bacteria, if present in a soil, tend to produce a healthier, and larger legume crop.

Apparatus. Root systems of as many different varieties of leguminous plants are you can obtain, as cowpeas, soybeans, alfalfa and clover; a knife; tripod magnifier; formalin, and a few fruit jars.

Procedure. Examine the roots of all the specimens you can obtain. Note the difference in the size of the nodules on the different varieties of plants. Examine the nodules with the magnifying glass. Bacteria themselves are too small to be seen even with the magnifier, but the nodules may be readily examined. Collect specimens of plants, showing nodules and place each specimen in a fruit jar properly labeled. Fill the jars with water to which has been added a little formalin. Seal the jars and the plants will be preserved indefinitely. Place them in the exhibit of agricultural specimens.

EXPERIMENT NO. 47.

INOCULATION OF LEGUMES.

Discussion. Bacteria attach themselves to plants and form knots or nodules, as they are called, on the roots, only where soil conditions are right and where the bacteria themselves are already established by some agency. Soil water is one of the best agencies for the spread of bacteria, but any method by which soil is transported from one field to another aids in their dispersal. In many fields nitrogen gathering bacteria are absent simply because they have never been transported to the field by a natural agency. On the other hand, if the soil in a field is acid, or wet, the bacteria die, or if no leguminous plants are grown on the field for five or six years the bacteria disappear. In some varieties of legumes the bacteria may be transported from field to field on the seed. This is true of such seeds as the cowpeas, but it is not true of the small smooth seeded legumes.

In regions where clover or alfalfa has been grown year after year, for a long time, inoculation becomes unnecessary for the reason that practically all the fields become inoculated naturally. Where a new legume is being introduced it is usually advisable to inoculate the soil. As a rule, bacteria common to one kind of legumes will not inoculate any other variety. Thus the bacteria of red clover will not inoculate alfalfa, but on the other hand the bacteria of sweet clover will inoculate alfalfa. This is an exception to the rule.

Apparatus. A flower pot; a small pan; magnifying glass; some seed, as alfalfa, clover, peas or beans, and roots of legumes.

Procedure. Examine, for nodules, the roots of plants which you have obtained from different fields. In obtaining roots be careful to remove the roots from the soil without stripping off the nodules. Pulling the plants or carelessly digging them will not disclose the nodules, for they will be broken off and left in the soil. Compare the amount of nodule growth on plants of the same variety obtained from different parts of the same field and from different fields. Examine the roots of garden peas or beans. Do the roots show nodules? Should there be nodules on the roots? Obtain some leguminous plants having nodules on their roots and cut off the nodules. Crush the nodules with the edge of any blunt instrument and pour water over them. After the water has stood for a while use it to water the plants in an experiment prepared as follows:

Take a pot of soil from some place where there is unlikely to be any bacteria common to the variety of the plant from which you removed the nodules. Plant in this pot of soil, seeds of the same variety as the plants from which you removed the nodules, and water with the solution prepared above. In this manner the young plant should become inoculated. After a month or so dig some of the plants and examine them for nodules. Has the inoculation been a success? Explain how this method of inoculation for alfalfa might be used in a practical way.

EXPERIMENT NO. 48.

INOCULATION OF LEGUMES.

Discussion. The one legume which is receiving most attention at present is alfalfa. The value of this crop for forage, the amount produced on an acre each growing season, and the improvement the crop makes in a soil, tend to make it worthy of the attention which it is receiving. Inoculation of the soil for alfalfa is one of the first things to consider in growing this crop. Of late, several methods have been devised for the inoculation of alfalfa fields. Bacteriological companies furnish bacteria for alfalfa in a gelatinous media, to be diluted with water and sprinkled over the seed before it is sown. This method has proven very effective, but it is expensive. One of the most common and a very excellent method of inoculation is to obtain soil from a field where the crop is growing and is known to contain bacteria, and spread this soil over the field to be inoculated. To inoculate by this method spread the soil containing the bacteria over the field thinly and at once harrow or drag it into the soil, thus covering it from the rays of the sun. This is best done on a cloudy day. The soil should be spread on the field as soon as possible after being taken from the alfalfa or sweet clover field. Demonstrate this method by an experiment.

Apparatus. Two four-inch flower pots; formalin; sieve, soil; gallon vessel; alfalfa seed, and oven for heating the soil.

Procedure. Screen some soil through the sieve to remove roots and stones, and fill the two flower pots with the soil. Place them in the oven and heat at the temperature of boiling water for two hours. This should sterilize the soil. Stirring the soil occasionally will help to heat all the soil. While the soil is cooling, place a teaspoonful of formalin in a pint of water and immerse a handful of alfalfa seed in the solution for two minutes. Remove the seed, rinse with pure water and after the soil is cool plant some of the sterilized seed in each of the pots of soil. Label the pots so they cannot become mixed. Water one of the pots with pure water. Water the other pot with water prepared as follows:

Fill a gallon vessel one-half full of soil obtained from around the roots of alfalfa or sweet clover plants that are known to have nodules on their roots. Fill the vessel the remainder of the way full of water. Stir the water and let it settle until it becomes almost clear. Pour off the water and use it to water the last mentioned pot of seed. Each time you prepare water by this method use fresh soil. At the end of a month or when the plants have made a good growth, examine the roots of the plants in each pot of soil. What difference do you note? Is there any difference in the amount of growth made by the two? Should there be a difference? Why?

EXPERIMENT NO. 49.

TIMOTHY.

Discussion. Timothy is the most important hay grass in the United States, and more acres are devoted to its growth than to any other tame grass. Timothy contains comparatively little muscle building food (protein) but in spite of this it is exceptionally good for work animals. When an animal is working it gets the protein in the grain feed and when idle very little protein is needed. Some of the things that make timothy popular as a hay crop are:

(1) An acre produces on an average five bushels of seed, and four quarts of seed will sow an acre. Therefore, the price of seed is always low, which is one of the reasons it is grown so freely.

(2) Its seed is distinctive in appearance and the farmer can easily judge it for purity.

(3) Timothy hay is very palatable and free from dust or hairy growths on the stem.

(4) Outside of the alfalfa regions of the West, most of the hay produced is grown in localities where timothy is adapted to climatic and soil conditions.

(5) Tmiothy is unusually free from disease or insect ravages.

Some of the objections to timothy are:

(1) It is very hard on the soil. If timothy is grown it should take a place in the rotation and the timothy sod should not be left standing for years at a time.

(2) Timothy contains very little valuable food, although it is a good roughage feed for work animals, as horses.

(3) As a general thing it is not a profitable crop for pasture.

Apparatus. Timothy plants and timothy seed.

Procedure. Examine the head of timothy. Would a head produce many seeds? What is the average length of a head of timothy? Compare a clover stem with a stem of timothy. Note the smoothness of the one as compared with the hairy growth on the other. Which is the most desirable in this respect? Why? Examine the roots of the timothy plant. Does timothy root deeply into the soil? Does the plant have many leaves? What is the average yield of timothy per acre? How long does a "Stand" last? Examine seeds of timothy for purity. Are other seeds hard to detect in the timothy seed? How is timothy seeded? When is the best time to sow timothy? Mount a nice specimen of timothy on a piece of cardboard as previously explained and place it with your other exhibits.

EXPERIMENT NO. 50.

CROP ROTATION.

Discussion. So much importance is attached to the subject of crop rotation and it is deserving of so much attention that the student should spend a considerable amount of time in its consideration. Only a brief discussion can be given here. Crop rotation is the term used to designate the growing of certain crops on the same field in regular order. Some farmers practice three-year rotations, others four, five or six-year rotations, while a few do not follow any system. Some of the advantages of rotation are:

(1) Certain plant diseases, insects and noxious weeds are destroyed.

(2) It adds humus to the soil.

(3) It distributes the labor throughout the year.

(4) It permits the plant food to be taken from different depths of soil.

(5) It produces a variety of crops and lessens the chances of failure.

(6) It keeps the soil producing more months in the year.

(7) It permits the use of soil building crops, (legumes).

(8) It promotes live stock raising which means increased fertility on the farm, and increased profit to the farmer.

There are so many different crops, so many types of rotation and so many things to be taken into consideration, that each person will have to figure for himself desirable rotations for his community. A profitable crop rotation for a general farm should include: (1) A "renovating" crop as clovers; (2) A "cleansing" crop which means a cultivated crop, as corn; (3) A small grain crop as wheat, etc. Take into consideration the kind of farming most practiced and for which the community is the best prepared, as grain farming, trucking, stock raising, dairying, etc. Consider soil, climate, market demands, labor problems, insects and diseases.

In planning the arrangement and the placing of crops selected it is necessary to have as many fields as you have crops in your rotation. This does not mean that they must be definitely divided fields, but there must be the same number of divisions of the land as crops in the rotation.

Apparatus. Access to an adjoining farm.

Procedure. List in the blank form on the opposite page the different rotations practiced on the farms of the community. Discuss these systems of farming, the rotations practiced and methods of improving them. In the lower blank form fill out some good rotations. Figure out three, four and five-year systems of cropping.

COMMON CROP ROTATIONS PRACTICED

FIELD NO.	1ST. YEAR	2ND. YEAR	3RD. YEAR	4TH. YEAR	5TH. YEAR	6TH. YEAR

SOME EXCELLENT CROP ROTATIONS

FIELD NO.	1ST. YEAR	2ND. YEAR	3RD. YEAR	4TH. YEAR	5TH. YEAR	6TH. YEAR

EXPERIMENT NO. 51.

DIRECTIONS FOR SCORING BARLEY.

(Adapted from Wisconsin Bulletin No. 212.)

Discussion. Barley serves as a ready money crop for most growers and is usually put on the market soon after threshing. It is not a good practice to place damaged barley on the market as the price will be cut severely; such barley could be fed on the farm at a greater profit. Different varieties should not be mixed when placed on the market as this makes the barley undesirable for malting purposes. Six rowed barley seems to be preferred by the brewers and growers.

Apparatus. Samples of barley to be examined.

Procedure. Score samples and place results on the following page, according to the outline given here.

(1) All kernels should possess the characteristics of their class and variety. Take one hundred kernels, constituting a fair sample of the grain. Count the kernels not true to type into three grades. In the grade badly off type cut one-tenth point for each kernel. In the next grade cut one-tenth point for two kernels, and in the best grade cut one-tenth point for every three kernels.

(2) Kernels should be of the same size and shape within the limits of the class and variety. Proceed as in No. 1.

(3) Six rowed barley should be yellowish white; two rowed barley nearly dead white in color. Discoloration from any cause should be severely cut. Proceed as under No. 1.

(4) All the kernels should be large and plump. Proceed as above.

(5) Barley should be mealy to somewhat glassy in texture, for the best results in malting and for feed. Take ten representative kernels and cut each crosswise. Cut one-tenth point for each kernel glassy throughout in its texture.

(6) The sample should be pure barley. Take a hundred kernels constituting a fair sample, count out the foreign grains, and for each foreign kernel cut one-fifth point.

(7) The sample should be free from dirt and weed seed. Cut sample one-fifth point for each per cent of foul material.

(8) The sample should be free from smutted, musty, broken or bin burned kernels and should have a sweet grain odor. From samples of a hundred kernels determine the per cent of damaged, smutted or bin burned kernels and cut one-fifth point for each per cent. Cut sample for bad odor from one to ten points.

(9) The standard weight is forty-eight pounds per measured bushel. Cut one point for each pound below forty-eight pounds per measured bushel.

(10) Barley should give a germination test of one hundred per cent. Cut one-half point for each per cent germination below one hundred.

OFFICIAL BARLEY SCORE CARD

NAME AND NO. OF SCORER ______________________

SAMPLE NO. ____________ DATE ______________

SCALE OF POINTS		1	2	3	4	5
TRUENESS TO TYPE OR BREED CHARACTERISTICS	5					
UNIFORMITY IN SIZE AND SHAPE OF KERNELS	5					
COLOR OF GRAIN	15					
SIZE OF KERNEL	10					
TEXTURE	10					
FREEDOM FROM MIXTURE WITH OTHER GRAINS	10					
PERCENT AND NATURE OF WEED SEED AND FOREIGN MATERIAL	10					
PERCENT OF DAMAGED, SMUTTY OR MUSTY KERNELS	10					
WEIGHT PER BUSHEL	15					
VARIABILITY	10					
TOTAL	100					

EXPERIMENT NO. 52.

RYE.

Discussion. The kernel of rye contains a living plant ready to develop. When the kernel of rye germinates it sends out temporary roots and later permanent roots. The root system of rye is almost exactly like that of wheat; except that while wheat has three temporary roots, rye has four. The two should be seeded in the same manner. (See Experiment No. 37.)

The head of rye is called the *spike.* It is made of parts somewhat similar to the wheat head. The rye head is composed of spikelets attached to the central stem or rachis, in two rows on opposite sides. Each spikelet consists of two parts, each division containing one kernel. The rye kernel is similar to the wheat kernel in appearance and structure.

Rye is used for the production of flour, for malting purposes, and as a feed for live stock. There is usually but one class of rye recognized in the market, but different grades are established on basis of the quality of the grain. Some of the factors that affect the grade of rye are: purity, soundness, size and weight per bushel. Examine samples of rye according to the following outline.

Apparatus. Rye plants; several samples of rye seed; flower pot filled with soil; heads of rye and balances.

Procedure. Plant kernels of rye one and three inches deep respectively and after they are three weeks old observe. Compare the ones planted deep with the ones planted shallow. Dig each and compare their root systems. Write a discussion on the "Seed Bed and Seeding of Rye." Make a drawing of a head of rye. Show the head complete and label it, "Spike." Make a drawing of a spikelet. Show the rachis. Make a drawing of the rye kernel showing the location of the embryo.

Take a sample of rye and make a study of purity by separating the sample into rye, other grains and foreign material. Figure by weight the percentage of the sample that is pure seed. Examine your samples for soundness by separating sound seed from broken, shriveled, or damaged kernels. Weigh both sound and damaged kernels and figure by weight the percentage of the sample that is sound. Examine the sample for size and classify the kernels in groups of large, medium and small. Determine the weight per measured bushel of the sample.

Repeat the above process, using other samples and write the results of your observations on the opposite page.

THE SCORING OF RYE

NAME ______________________ DATE ____________

SAMPLE NO.	PERCENT GOOD SEED	PERCENT IMPURE SEED	PERCENT OF TRASH	SIZE		
				LARGE	MEDIUM	SMALL
1						
2						
3						
4						

FIELD EXERCISE.—CHINCH BUGS.

Chinch Bugs are among the worst insect enemies of wheat. They are easily recognized as small dark colored insects with white wing covers. See Figure No. 19. Chinch bugs suck the sap from the wheat plant and thus weaken its vitality. The bugs live over winter in straw, chaff, weeds, and bunch grass roots. Go into the fields of wheat and oats stubble and look in bunches of straw, weeds or bunch grass for chinch bugs. Take the specimens found to school and place them in a bottle of water and formalin as explained. Label, and place the bottle in the school collection. Learn to iden.ify the chinch bug at sight. Name other plants besides wheat that are attacked by the chinch bug. Where does the chinch bug go after the wheat is cut?

EXPERIMENT NO. 53.

TESTING SEEDS FOR VITALITY.

Discussion. The farmer's corn crop depends primarily upon the power of the seed to grow. Not only must it be able to grow, but it must grow vigorously. In Experiment No. 23, "Seed Condition," is given fifteen per cent. In that experiment you attempted to tell merely by examination whether or not a seed would grow. No person can tell definitely whether a seed will grow or not, simply by examining it, although by certain signs a very intelligent guess may be made. The only definite way to determine this point is by trying to germinate the seed under actual conditions. The following are some very simple and common forms of seed testers especially useful for germinating corn.

Figure No. 19.
Chinch Bug.
(Photograph by Kansas Experiment Station.)

Apparatus. A strip of white muslin or similar cloth three feet long and twelve inches wide, and ears of corn to be tested.

Procedure. In the center, six inches from either edge, make a heavy black line lengthwise of the strip of cloth. Mark lines across the goods three inches apart. Number each of the spaces thus made and place a tag upon each ear of corn numbered to correspond to a square on the cloth. Moisten the strip of cloth thoroughly and then take kernels from each ear and place them in the squares as follows: Take two kernels from opposite sides of the ear at the tip, from the center and from the butt. The tip and butt kernels should be taken about three inches from each end. Arrange the kernels in the square marked with the same number as the ear, so that the tip kernels are two inches from the edge of the cloth the center kernels near the center of the square, and the butt kernels near the center black line.

When all the spaces on the cloth are full, or when you have placed in the squares kernels from all the ears, carefully roll up the cloth and tie it around each end and at the center. The roll is next moistened thoroughly by soaking it in a pail of water from two to twelve hours. It is then to be placed in a warm room and left from five to six days, being watered in the meantime whenever necessary. Finally it is unrolled and the kernels examined.

This method permits an examination of the roots of the plants. It is a convenient form of tester because it takes very little room. By painting a face on the roll before it is placed in the water it can be made to present the appearance of a rag doll which helps to hold the interest of the smaller children.

EXPERIMENT NO. 54.

TESTING SEEDS FOR VITALITY.

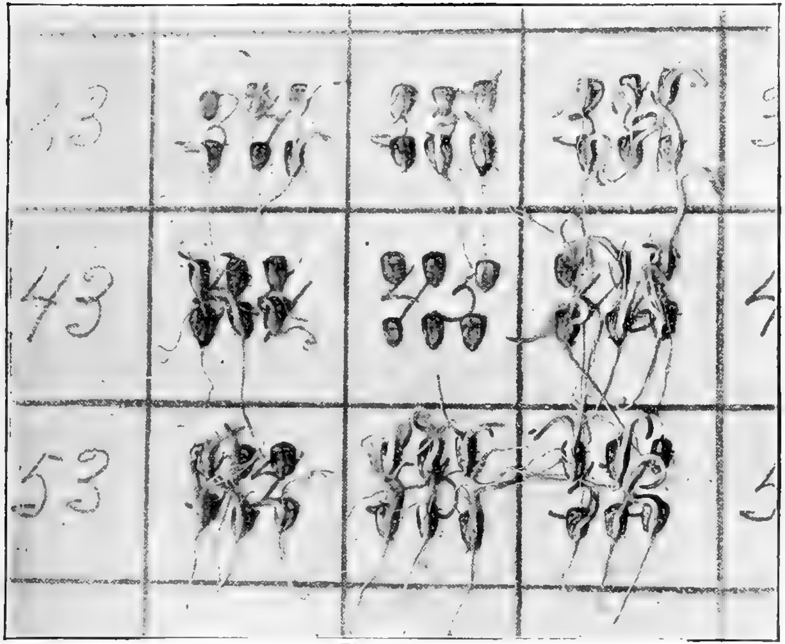


Figure No. 20.
Seed Tester.
(Photograh by Kansas Experiment Station.)

Discussion. Many people desire a sand tester for testing seed corn and it has some advantages. If you desire to try testing seed corn in a sand tester proceed as directed in the experiment below.

Apparatus. A wide shallow box about two feet square and six inches deep; some fine sand; seed to be tested, and two pieces of cloth each as large as the box.

Procedure. Fill the box within an inch of the top with fine sand and level it carefully. Cut a piece of white cloth the same size as the inside of the box. Spread out the cloth and fasten it on a smooth surface so that it will not be wrinkled. Mark the cloth into two-inch squares by means of heavy black lines. Number each square thus made and spread the cloth over the sand in the box. Lay six kernels from each ear of corn to be tested in one of the squares, with their germ sides down. Number the ears to correspond to the squares. When the tester is full spread the other cloth over the kernels, being careful not to disturb any of them. Cover the top cloth with one-half inch or more of fine sand and moisten thoroughly. Leave in a warm place and water the tester every day. After about five or six days your test will be ready to examine.

Remember that the kernel that germinates first is not always the best kernel. The kernel that grows most vigorously, that has the best root system, and develops the best plant from its stored up food is the best one from the standpoint of growth. It is well to let the plants grow for about two weeks, if you do not need the tester, and examine the plants at the end of that time.

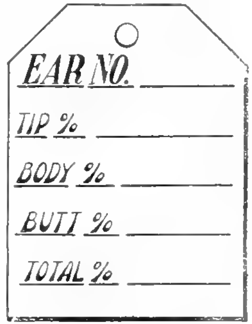


Figure No. 21.
Corn Ear Tag.

If it required fourteen ears of corn to plant an acre and one of the ears planted was dead, what percentage of the corn crop would be lost at the start? If you want to label each ear as it is tested use a card like the one shown in Figure 21, and fasten it to the ear with a rubber band or piece of string. Fill out the card showing the percentage of germination of the tip, body, and butt kernels respectively, and figure the percentage of germination shown by the entire ear.

EXPERIMENT NO. 55.

TESTING SEEDS FOR PURITY.

Discussion. The importance of good seed should be impressed upon every farmer, and in such a manner that he will insist upon seed absolutely free from dangerous weed seed. Many farmers sow the weeds they most dread in low priced or inferior seed. A number of cases are known where unprincipled farmers sold their entire crop of seed, saying that the same contained too much dangerous weed seed for them to sow on their fields. Can a farmer afford to buy and sow such seed, especially if his land is free from these weeds?

See to it that grass seed is free from all foreign material true to name, free from disease, and well bred. By foreign material is meant anything that is not seed of the variety specified. Perform the following exercise which is a simple and easy method of examining seeds for purity.

Apparatus. A handful of different kinds of seeds to be examined; such as clover or timothy; tripod magnifier, if you have one, and some paste. (A very excellent paste for sticking samples to the page is the white of an egg. Simply take the white of an egg and spread it as you would any other paste. It is transparent and will stick the seeds firmly.)

Procedure. Take from the supply of seeds to be examined a small quantity—what you would guess to be a hundred seeds.

Separate this small sample into three piles. In one pile place all of the well-formed seeds of the variety that is being examined. In the second pile place all of the weed seeds and in the third pile place all of the material that is not seeds together with broken seeds, husks, etc.

Place a thin coating of paste in each of the three squares on the opposite page and to this paste stick the three piles of material each in the proper square. Count the number of good seed and the number of weed seed. What is the percentage of weed seed? Do you know the names of any of the weed seeds? Are they very harmful weeds? What is the percentage of foreign matter? Is it enough to be of any serious concern? Is your sample a good or a poor one?

GOOD SEED. | WEED SEED. | FOREIGN MATTER.

Percentage of good seed...

Percentage of FOREIGN MATTER...

Percentage of weed seed...

Name of the weed seeds...

....

....

In your judgment, what is the sample worth per bushel for seed?

FIELD EXERCISE.—CLUB PROJECT.

Club Project: A wheat, oat, corn, potato, or tomato club makes an interesting method of studying profitable crop production. The Boys' and Girls' Clubs being organized everywhere are a systematized movement along this line and are producing wonderful results. The club or clubs should be organized under a local leader and "follow up" instructions obtained from the State Department of Agriculture. Each member of the club should arrange to grow a plot of the crop to be studied, the size to be determined by the rules governing the club.

The girls might organize a separate club or they might grow a small plot of the crop under consideration and study the life history of the plant. Write to the State Leader of Boys' and Girls' Club Work and you will receive valuable and interesting information on this subject.

EXPERIMENT NO. 56.

TO DETERMINE THE VIABILITY OF WHEAT.

Discussion. Upon the viability of seeds our entire future crop depends and if we fail to sow seeds that will grow, our time, effort and money are wasted. To determine the viability of seeds the germination test must be applied. Test grass seed for germination as follows:

Apparatus. One hundred seeds of the variety to be tested; preferably clover or timothy seed; two dinner plates and a piece of cloth or some blotting paper.

Procedure. From your sample select one hundred seeds that represent the average grade of the whole, and place them between moist cloth. Place the moistened cloth containing the seeds in one of the plates and turn the other plate over the seeds to keep the moisture from escaping readily. Keep the seeds in a warm place for three or four days. It may be necessary to moisten the cloth several times during this period. Be careful that water is at no time left standing in the plate.

At the end of three or four days count the number of seeds that have germinated. What is the percentage of viability of this sample? Do you think that it would not be profitable for the farmer to test samples of all his seed for viability? What is your idea of the meaning of this term? Look in the dictionary for the meaning of the word, viability.

Remember that the germination test does not entirely determine the value of seeds. They must not only grow but they must grow vigorously and be capable of producing large healthy plants. Usually seeds that test well are plump and heavy. Examine different samples paying attention to this point.

EXPERIMENT NO. 57.

CORN SMUT.

Discussion. Smut is found on many cereal crops and on some of them it does a great deal of damage. Corn is one of the plants affected by smut and in order to combat it successfully we should be able to recognize the smut infested plants. Corn smut differs from other smuts in that it may appear at any place on the stalk, or ear. It has been found on root and tassel alike and upon all intermediate parts. The swollen masses of black powdery substance, called spores, of which the smut is composed can be found at any time during the summer or fall. Corn smut appears as soon as the corn is up and continues to spread rapidly until the corn is mature. It can be controlled best by the prompt removal and burning of all diseased plants. Heavy applications of manure and low moist fields are conditions which help to spread this disease.

Apparatus. A neighboring field of corn.

Procedure. Go into the corn field and find stalks or ears of corn affected with smut. Draw a picture to show the affected part of the plant. Find plants affected in different parts. Explain the damage done by the smut in the field examined. Open some of the spore masses and note the black powdery spores.

Remember that each spore is capable of living over winter and starting the disease on new plants. Bring to school an ear of corn that is affected and plant it in a clean jar. Cover the specimen with clean water and add a few tablespoonfuls of formalin. Cover or seal the jar tightly and the specimen will keep perfectly. Label the specimen and place it on a shelf for the inspection of any who may be interested.

EXPERIMENT NO. 58.

PARTS OF A FLOWER.

Discussion. The crowning part of a plant is the flower because it is the flower that produces the seed which in turn reproduces the plant. Only flowering plants bear seed. A perfect flower is composed of four main parts, the calyx, corolla, stamens and pistil. Remember that a blossom may contain a number of flowers, each a complete unit within itself. For example a single clover blossom contains hundreds of flowers.

(1) *Calyx.* The calyx is the outside portion of the flower composed of little green leaf-like parts, more or less fastened together at their base. At a glance it appears to be a continuation of the stem. See Figure No. 22.

(2) *Corolla.* The colored portion of the flower is called the corolla and it is this part which gives the flower its beauty. It is composed of a number of little leaves which are called petals.

(3) *Stamens.* The stamens are slender like parts standing rather erect around the inside of the corolla. The enlarged part at the top of the stamens is called the anther. See figure number 22. The anther of the flower is an important part for you to identify, since it contains a yellowish dust called pollen.

(4) *Pistil.* The pistil occupies the center of the flower and is made up of two main parts, the enlarged base or ovary and the slightly enlarged or branched top called the stigma. It is at the base of the pistil in the ovary that the seeds develop. However, there will be no seeds developed unless the pollen from the anther is in some manner lodged upon the stigma. This pollen is lodged upon the stigma by various methods such as rain, wind, insects and birds.

The beautiful color of the corolla is useful to the flower for attracting insects that carry pollen from flower to flower. Sometimes the seed crop fails because pollen does not reach the stigma and fertilize the tiny undeveloped seeds in the ovary.

Apparatus. Blossoms from as many plants as you will have time to examine; any sharp pointed instrument as a knife, and a tripod magnifier.

Procedure. Take a flower that shows the four main parts and by the aid of the magnifying glass separate the parts. The figure on the opposite page should help you to do this. Sketch each part and label the same. It is a good plan to mount the parts of a flower and label each part. Write in your book five questions concerning the parts of a flower and discuss the questions in class.

FIELD EXERCISE.—PLANT STARCH.

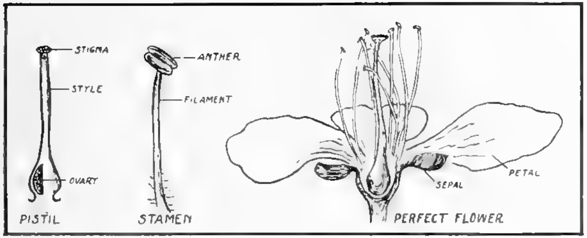


Figure No. 22.
Parts of a Flower.

Some seeds have peculiar methods of storing food, and many of them are interesting aside from their economic value. Four-o'clock seeds are peculiar in this respect. These seeds have the starch stored outside the seed-leaves, the seed-leaves are wrapped about a ball of starch in a "life-and-death" grip. For examination soak them thoroughly, and carefully remove the tough outer covering or testa. Start a large number to germinating and dissect a few each day.

Note how the starch is gradually absorbed before the seed-leaves forsake the shell to come to the surface of the ground. Compare them with other seeds in this respect.

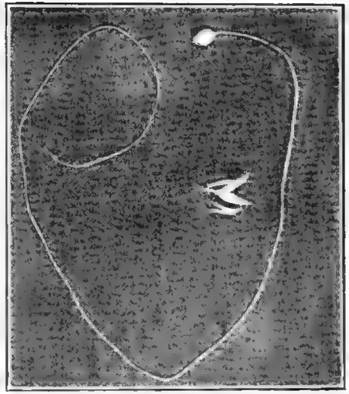


Figure No. 23.

(Courtesy Kansas Agriculture College.)

The corn flower, showing the silk attached to the embryo kernel called the ovule, and the pollen sacs found at the tassel.

EXPERIMENT NO. 59.

THE HESSIAN FLY ON WHEAT.

Discussion. The Hessian fly was first found in the United States in 1779 near the landing place of the Hessian soldiers on Long Island. The little fly which they brought with them has done more damage, many times over, than the soldiers did. The fly attacks the wheat both in the early fall and in the spring. The grown fly or adult is a slender long legged gnat. It lays its eggs on the upper side of the leaves near the stem. Soon each egg hatches and the little larva or maggot that is produced finds its way down between the leaf sheath and stem where it begins to feed, and does a great deal of damage. As the maggots grow they turn from reddish to white in color and finally pass into the "flaxseed" stage and in this stage usually exist over winter. If we examine the early grown wheat when it begins to stool we can find the eggs on the leaves. Later in the fall we find the maggots at the very base of the leaves, and lastly the "flaxseed" stage of the fly.

Apparatus. Old wheat stubble; early sown wheat or volunteer plants of wheat or oats and a magnifying glass.

Procedure. Go to the field and examine the old wheat stubble for the little flaxseed appearing objects. Look for them on the early sown wheat. Also look for the eggs on the blades of the plants. Examine some of the flaxseed or pupa as they are called in this stage. It is from this pupa that a small blackish fly or gnat hatches in the spring and at once stars laying eggs. Learn to identify the fly at sight. Note how it affects the wheat both in the fall and in the spring. Suggest three methods of controlling this insect. Note the date and location of the earliest wheat sown in your community; the latest sown. In the following summer note which is the better wheat. Has the ravages of the fly had anything to do with the difference? When is the average date of sowing wheat in your community?

Co-operation is an essential factor in eradicating or controlling the ravages of the Hessian fly. If one farmer sows wheat early, that field furnishes a place for a fall brood and all the adjoining fields will be infested with the fly the following spring no difference at what time in the fall they were seeded. Volunteer wheat is a menace to the succeeding crop and should not be allowed to grow. There is no doubt that volunteer wheat serves to enable the fly to produce an extra brood and to carry it on in great numbers to the regular crop.

EXPERIMENT NO. 60.

WHEAT RUST.

Discussion. The loss of wheat from rust in the United States exceeds that caused by any other disease or insect pest, and is thought to be greater than the loss from all other diseases combined. Wheat rust may easily be found on mature plants and is apparent on both stem and leaf. While rust does not exist on the wheat kernel in a manner that is readily noticeable, yet the little spores of the disease are present just under the bran coat. It is not definitely known how harmful the rust spores are in the kernels.

We commonly hear of two kinds of rust and they are called the red rust and the black rust. In reality the two rusts of wheat are the stem rust and the leaf rust. The two are different and each has its red and black stage. The stem rust is the more harmful, the leaf rust being comparatively harmless. The two rusts, for our purpose, may be considered together. The black rust is the form the rust takes late in the season. The rust appears in the plant early in the season and multiplies rapidly throughout the entire summer, spreading from plant to plant. It may be detected on the plant as long streaks along the stem or leaf, very narrow and quite definite. Sometimes they become mere points of red or black spore masses. This rust feeds upon the juices of the plant and weakens it. Due to the lack of food the kernels do not fill out properly, are light and chaffy and the stalk apparently ripens before the kernels are mature.

The control of rust has not been completely worked out although it has been given a great deal of study. Some of the best methods to use are to keep all stubble plowed under, all weeds and grasses cut around the field, all shrubbery removed during the winter, and the planting of good healthy seeds that will grow vigorously. Some kinds of wheat are more rust resistant than others; Durum wheat being an example of a rust resistant variety. Study rust carefully and note its ravages throughout the entire year in the wheat crop of your community.

Apparatus. If this experiment is taken up in the fall, get some stems of wheat from a protected straw stack. If possible, plants that have been collected during the summer should be used; a little formalin; a small bottle, and a tripod magnifier.

Procedure. Take the plants which you have and examine them for a little thread-like discoloration that runs lengthwise of the stem or leaf. Make a drawing of a wheat plant and show these little streaks of rust. Are they reddish in color or black? What damage do they appear to do from your examination of them in the field? In a field of wheat count the number of diseased stalks in a given area of plants and count the number of healthy stalks. Figure the percentage of the plants that are diseased. Ask some farmer to tell you of his experience with rust. Find out if he has tried to control rust by rotation, or by any of the methods mentioned above. Take a number of stems and leaves affected with rust and cut them into even lengths short enough to go into the bottle you have prepared. Place them in the clean bottle, cover with water to which you have added a teaspooful of formalin, and cork the bottle tightly. Label the exhibit and place it with your collection of specimens.

EXPERIMENT NO. 61.

STINKING SMUT OF WHEAT.

Discussion. Stinking smut of wheat has been known and dreaded for a long time, treatment having been used on the seed as early as 1655. The black dust or spores of the smut completely fill the ripening kernels and show a remarkable tendency to spread. A single kernel may contain thousands of the smut spores, which are like little seeds in their nature. They are blown around by the air and light on the healthy kernels. Here they remain stuck to the kernels until the seed is sown the following spring, at which time they start to grow along with the plant and ripen in the plant as it matures. The best way to control stinking smut is by treating the seed, as most of the spores that do damage live over winter on the seed. The spores are so small that they stick to the kernel without being noticed.

Grains of wheat diseased by stinking smut are somewhat larger than healthy ones. The kernels are really "Smut Balls," and when broken open disclose a mass of blackish powder, or spores which have a disagreeable odor. Wheat affected with stinking smut is very inferior for flour and is worthless as seed unless it is treated. In the wheat bin the odor often discloses the presence of the disease. While stinking smut is readily seen only in the diseased kernels it exists in the stem as well, and sometimes a crop of wheat is seriously damaged by the smut without its being apparent in the grain. This is especially true if the wheat ripens early, for in such a case the smut if present does not have time to reach the kernels.

Apparatus. Heads of wheat that have been affected by stinking smut; (these should have been collected from the field when the wheat was ripe) wheat from a bin that is affected with stinking smut; a tripod magnifier; formalin, and from a peck to a bushel of wheat to be treated.

Procedure. Examine heads of wheat and look for smutted kernels. Break them open and note the contents. Note the odor. Examine the large sample of wheat which is to be treated and see if you can find any smutted kernels. Treat the sample for stinking smut as follows:

Prepare a solution for sprinkling the wheat by mixing formalin with water at the rate of one poud of formalin to fifty gallons of water. A pint of formalin may be considered as one pound. It requires a gallon of this solution for one bushel of wheat, so if you wish to treat one bushel of wheat, one-fiftieth pint of formalin and one gallon of water should be mixed. Place the wheat to be treated on a piece of canvas or on a smooth floor. Sprinkle the solution over the wheat using a sprinkling can or broom. Keep stirring the wheat so that every kernel will be reached by the solution.

Then heap the wheat in a pile and cover with an old sack or anything that will keep the formalin gas from escaping. It is this gas which kills the spores. Leave the pile covered for two or three hours and then spread it out to dry.

If possible, treat some seed for the farmers in your community and watch the results during the growing season. Compare the fields planted with treated seed with those planted with untreated seed. Write a discussion upon this subject in your notes.

FIELD EXERCISE.—THE HOME GARDEN.

Measure your home garden and find the amount of space devoted to vegetables. Make a list of all the vegetables grown in your garden. How many kinds are grown? Compare this list with the lists of other pupils. Make a list showing all the different kinds of vegetables that are grown in your community. By comparing the size of the gardens of the members of the class determine the average size of the gardens in your community.

Plan a garden for the spring showing where each row of vegetables will be and plan for a succession of vegetables. Make a list of the vegetables you plan to plant and list the date at which they should ordinarily be planted. Make a complete drawing of your garden before planting time. Compare your drawing with the drawings of other students.

Note:—A prize might be awarded for the best planned vegetable garden, or the best executed plan. Such a garden plan will furnish the basis for a great deal of study and should be utilized by the up-to-date class.

EXPERIMENT NO. 62.

LOOSE SMUT OF WHEAT.

Discussion. Loose smut of wheat differs from stinking smut in that it attacks both kernel and chaff. It has no distinguishing odor and ripens when the wheat is in bloom. By harvest time the spores have mostly blown away, leaving a naked stalk in place of the wheat head. Loose smut is easily found in the field just before the wheat begins to ripen. The black powdery heads with the kernels destroyed can be readily seen even at a distance. The spores from these black spore masses are carried to neighboring healthy plants, which are in full bloom at this time. If a spore alights on the ovary of a flower it infects the germ of the growing seed. It does not seem to injure the germ and the kernel grows to maturity However, when the kernel is planted the next year, the spore grows along with the kernel and destroys the entire head. Loose smuts attack both wheat and barley. Since the spores do not attach themselves to the outside of the kernels, the disease requires special treatment for prevention.

Apparatus. Heads of wheat affected with loose smut; a tripod magnifier; paste, and diseased kernels of wheat. (The wheat should have been collected during the summer).

Procedure. Examine the smutted heads. What has become of the kernels? At what stage in the life of the plant do the spores mature? Do you consider the disease very destructive? Count the number of diseased and healthy plants in a given area of the wheat field and figure the percentage of the field that is affected. From this and from the yield of the field when harvested, figure the bushels lost due to the disease. Examine one of the little black particles or spores under the magnifier. What does it resemble? What will it do if placed under the right conditions? What might a spore be called as far as its purpose is concerned? Paste a head of diseased wheat in the space below. Shake off a few of the blackish powdery spores and place them on a spot of paste below. Label them.

No satisfactory treatment has been worked out for this disease. Rotation of crops and the destruction of stubble are both aids in its control. A hot water method has been worked out but it is not entirely satisfactory. A long time formalin treatment appears to be the more promising. The best thing to do is to purchase seed from a smut free district, and to change the location of the wheat field each year. Although loose smut is rather slow to become established, yet when once present on a farm it is very hard to eradicate.

EXPERIMENT NO. 63.

TREATING OATS FOR SMUT.

Discussion. Smut in oats is very similar to the loose smut of wheat. The smut usually appears as a black powdery mass and may destroy the entire head of grain. The smut spores become ripe after the grain has headed and are distributed over the field by the wind. Also, the ripened spores are scattered and disseminated by means of machinery, sacks, wagons, etc., at threshing time. These spores cling to the kernels and when the grain is planted the following season the smut is sown with the seed. The spores germinate at the same time the seeds do and grow along with the plant until heading time. At this time the fungus ripens its spores in the heads and produces a black spore mass where the head of grain should be. The only way that has proven practical to prevent the spread of this disease, is to plant seed free from the spores. To free oats from the spores of smut, the use of the formalin treatment is the best so far devised.

Apparatus. One half bushel or more of oats; an ounce of formalin; three gallon pail, and a piece of clean cloth that will cover the oats.

Procedure. Formalin as a disinfectant for smut in oats should be used at the rate of one pound of formalin to forty-five gallons of water. Add one ounce of formalin to three gallons of water, which will be about the right proportion and stir the mixture. Place the oats on a level floor and sprinkle them with the solution until they are thoroughly moistened. After they are all moistened heap them in a pile and cover with a piece of cloth. It is the formalin gas that kills the spores by penetrating under the husk, where the spores have lodged. Therefore, the heap must be covered carefully to prevent the gas from escaping. In about two hours spread the oats out to dry and the treatment is complete. This treatment is very effective and is so simple that it seems strange that farmers will plant untreated seed in smut infested areas.

The Dipping Method. If preferred the oats may be treated by dipping them sack and all into the solution for a short time, and then spreading them out to dry. The time it is necessary to leave the oats in the solution varies with the size of the sack, etc. As a rule they should become moistened throughout in ten minutes. Do not leave the oats submerged too long for it will impair the vitality of the seed. After treatment the grain should be placed where there is certain to be an entire absence of smut spores. It is well to treat oats only a short time before they are to be sown.

If possible, treat the oats for some farmer in your community and record results throughout the summer. If heads of oats that are affected with smut can be had, examine them so that the disease may readily be recognized upon its appearance. Write a discussion on "The Damage of Smut to Oats." Look up the immersion method and the hot water method sometimes used in the treatment of oats for smut.

EXPERIMENT NO. 64.

PROPAGATION OF PLANTS.

Discussion. Of all the duties with which the farmer is encumbered, there is none of more importance than the reproducing of desirable plants. The methods by which plants may be propagated are by spores, seeds, and by several methods of division or bud growth, such as creeping stems, roots, stocks, tubers, cuttings, budding and grafting.

Spores. Spores differ from seeds in that they do not contain a young plantlet. The lower forms of plants reproduce by spores. Give an example of reproduction by spores. In the main are plants that reproduce by spores beneficial or harmful?

Layering. Many plants reproduce by creeping stems or root stocks. In layering, a branch is so placed in the soil as to cause it to put forth roots and shoots, thus producing new plants, the branch in the meantime remaining attached to the parent plant. After getting started, the new plants are severed from the main stock and become independent plants. White clover branches take root and form new plants in this manner, which enables this clover to persist where other clovers are exterminated.

Cutting. Many plants may be reproduced by cuttings, such as clover, alfalfa, geraniums, etc. A cutting is simply a portion of the plant which contains a few leaves or buds, and when inserted in soil or water begins to grow. Cuttings are divided into three classes, hard-wood cuttings, soft-wood cuttings, and root or tuber cuttings.

Grafting. Many plants are profitably reproduced by grafting, by which method plants are reproduced true to type. The common grafts are the cleft graft, root graft, top graft, whip graft, and ring graft.

Budding. Plants are reproduced true to type and with great ease and rapidity by budding. By this method a single bud is placed on the stock of a closely related variety of plant. Figure number one, page 82, shows the most common method of buildings.

Apparatus. Materials for making grafts; a box of clean sand and cuttings of a number of plants.

Procedure. Make the different kinds of grafts shown on page 82. In making grafts observe the following points. The cambium layers of the two parts must touch. The joints must be sealed tightly with some substance, as wax. Only closely related varieties can be grafted upon one another.

Take the cuttings which you have and insert the slips into moist sand, packing it well around the stems. Remove all but one or two of the leaves. Keep the sand warm and moist and watch the growth from day to day. On the opposite page write in the blank space provided, the best method by which each plant given may be reproduced. Also, mention other plants giving methods by which they may be reproduced.

This subject is a broad and valuable subject, especially to the horticulturalist, and should be made the basis of several days study. Students will do well to perform many experiments along this line. Consult other literature upon the subject of the propagation of plants. See Farmers Bulletin, Number 157, United States Department of Agriculture.

PROPOGATION OF PLANTS

NAME OF PLANT	REPRODUCED BY	REPRODUCED BY	REPRODUCED BY
CORN			
CLOVER			
WHEAT RUST			
CORN SMUT			
APPLES			
POTATOES			
GERANIUMS			

THE PROPAGATION OF PLANTS.

EXPERIMENT NO. 65.

WEEDS AND THEIR CLASSIFICATION.

Discussion. The cost of the cultivation of intertilled crops such as corn, for example, is the major portion of the entire cost, yet it is possible that outside of holding the weeds in check, we do the corn very little good by intertillage. When land is fallow a soil mulch helps to save moisture, but when a soil is filled with thousands of little rootlets all demanding moisture, it is possible that very little of the capillary moisture ever reaches the surface. Therefore, if there were no weeds in a field, practically all of the capillary moisture would reach the plants, and the continued cultivation would be of doubtful value. This point is strongly disputed and is being studied by many people.

If you can find a field that is reasonably free from weeds, try leaving a small portion of the field uncultivated after planting and compare results of the cultivated and uncultivated areas in bushels at harvest time. A detailed discussion of this point is given in the United States Bulletin, Number 257. At the least, we may reasonably conclude that an eradication of the weeds from the farm would greatly reduce the amount of labor and loss now suffered. But to eradicate weeds demands a knowledge of their life habits. In the following experiment endeavor to become acquainted with our common weeds.

Apparatus. Large sheets of paper; paste and some large blotters or newspapers if blotters cannot be had.

Procedure. Bring to school samples of weeds common to the local fields. Identify each by its common name. Discuss where it is commonly found, whether in cultivated or uncultivated fields. What is the method of the spread of each? Discuss the distinguishing characteristics of each plant. Press specimens between blotters or newspapers. Let them dry in press, changing the blotters a time or two depending upon the size of the plant being pressed. When properly pressed, mount each specimen on a large sheet of paper and label. To mount specimens, use small pieces of paper or gummed labels pasted over various parts of the plant and attached to the mounting sheet. This method of mounting will hold the specimens very securely. See figure 26. The specimens if carefully mounted and classified, will become a very valuable part of your agricultural work.

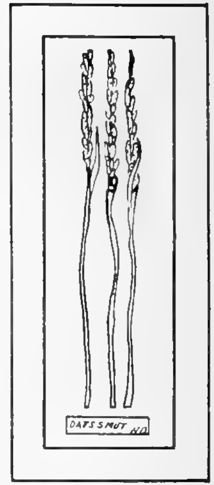


Figure No. 26.
Mounted Specimen.

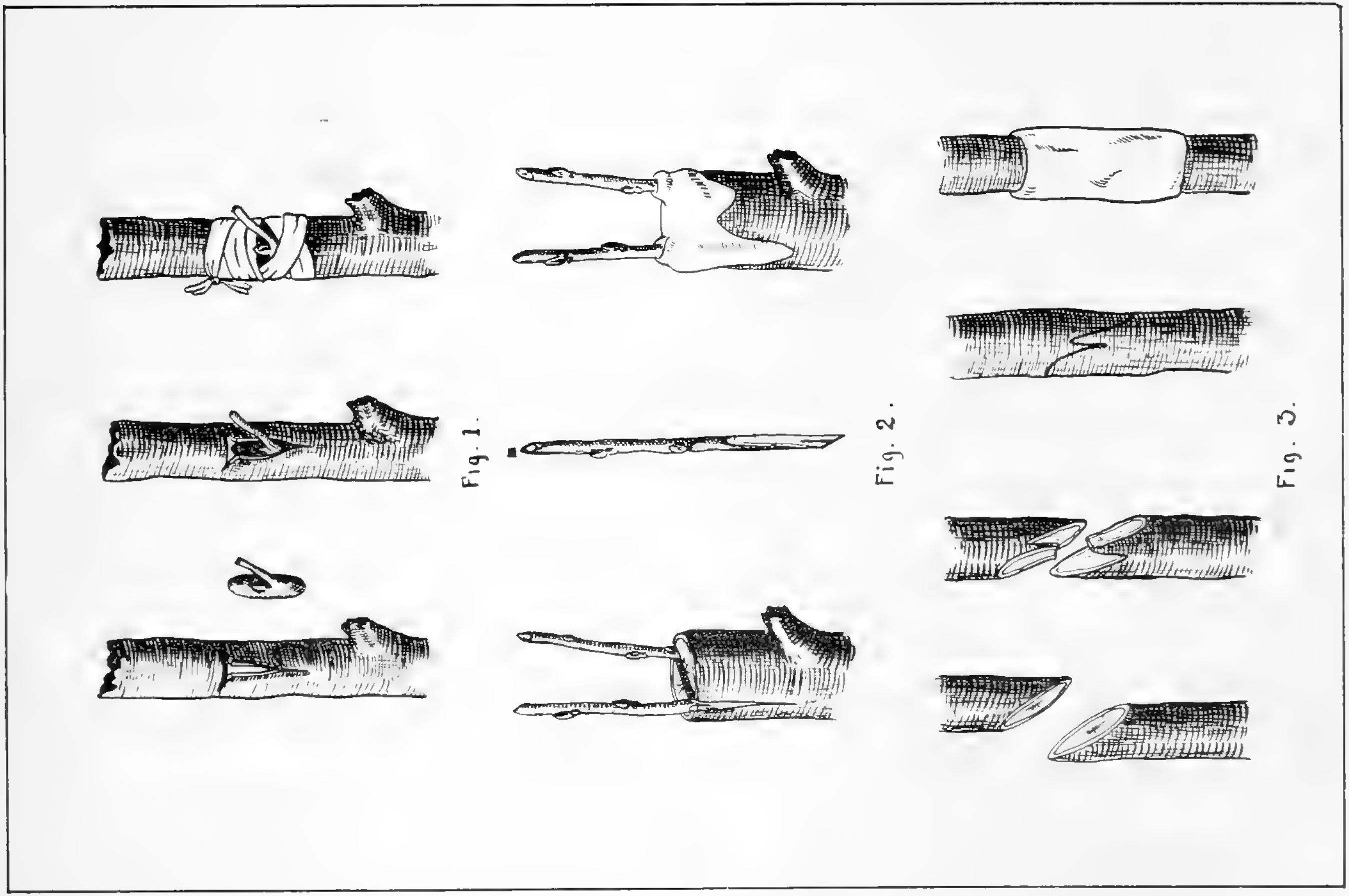


Fig. 1.

Fig. 2.

Fig. 3.

EXPERIMENT NO. 66.

WEEDS AND THEIR CLASSIFICATION.

Discussion. Weeds are classified in three groups on basis of the length of life of the individual plants. The plants that sprout up, mature and produce seed in one growing season are called annuals. Those that grow one season and ripen their seed the next year are called biennials; while the plants that reproduce and yet continue to live year after year are called perennials.

The annual and biennial weeds are troublesome mainly through their prolific seed habits, but the perennial is the most troublesome of all the weeds. Each of the perennials requires special attention for its eradication. Literature published by State and United States Departments of Agriculture should be consulted. Such perennials as wild morning glory, Canada thistle, Johnson grass, and the like are among the most troublesome of this class of weeds.

Figure No. 27.
Russian Thistle.
(Courtesy Botanical Department, Kansas Agricultural College.)

In the main the annuals and biennials are controlled by destroying the plants before they go to seed. The Russian thistle shown here is a good example of the prolific seed habits of some of the weeds. This plant grows like a small bush and in the fall ripens thousands of seeds. When the fall winds come, the bush, which is almost round breaks off at the ground and goes rolling across the field spreading seed everywhere. For as much as twenty miles one plant has been known to spread its seeds in one season. In some of the southern states, as Texas, the horde of travelling weeds of this variety pile up on the fences until the wind blowing against them, pushes the fence over and then away they go until they meet the next obstruction.

Apparatus. Specimens which were mounted in Experiment No. 65 and any other plants you desire to classify.

Procedure. List each of the plants by its common name and place it in the proper column in the adjoining blank form. Discuss the best method for controlling each weed. Discuss its most harmful characteristics. Define annual; biennial; perennial.

WEEDS AND THEIR CLASSIFICATIONS

ANNUALS	BIENNIALS	PERENNIALS	HOW CONTROLLED

EXPERIMENT NO. 67.

DISTRIBUTION OF WEED SEED.

Discussion. In the previous exercise we have mentioned something of the prolific habits of weeds as concerns the seed. We will discuss here some of the most common methods of seed dispersal. The remarkable habit of the Russian Thistle has been noted but consider for a moment other seeds almost as well equipped to travel as the Russian Thistle.

Apparatus. As many kind of seed as you can find which may be classified as weed seed.

Procedure. It is best to take the class into the fields and obtain the different kinds of weed seeds. Discuss each different kind of seed as it is found and determine how it is disseminated. Make a list of the seeds you have identified and give the most common method of seed dispersal of each. Note especially seeds that float on water; seeds that are transported through the air, and those that cling to passing objects.

EXPERIMENT NO. 68.

BLUE PRINTING PLANTS.

Discussion. In studying plant structures as leaves, root systems, etc., blue prints may be used to a great advantage to compare plants at times of the year when actual specimens cannot be had.

Apparatus. Blue print paper; blue print frame, and specimens to be printed.

Procedure. Place the specimens on the glass plate in the Blue Print Frame or on a piece of glass, if no frame is to be had, and place the blue print paper over the specimen with the prepared side of the paper against it. This should be done in a darkened room. Place the back in the blue print frame or cover the blue print paper with something that will hold it firmly against the specimen and then expose it to the bright daylight. Remove the paper and at once rinse it gently in water. After drying, mount the blue print and place it with the Agricultural Collection. The time required for exposure of the paper may vary within wide limits depending upon the brightness of the light, kind of paper and the density of the specimen. A few trials will give you the correct time required for exposure of the paper.

EXPERIMENT NO. 69.

CLOVER CROP PESTS.—SEED-CHALCID.

Figure No. 28.

Work of Clover Seed Chalcis Larvae on Alfalfa. (Photograph from Kansas Experiment Station.)

Discussion. The abundant clover seed Chalcid was once thought to be an enemy of the seed midge, but is now known to be one of the worst pests of the clover field. The little black fly-like insect may be seen around dead or dying clover heads during the summer. It is principally found on red clover, crimson clover and alfalfa. The fly lays its eggs in the undeveloped clover seed just before the seed coat hardens. The larvae which soon result eat the interior of the seed and leave only a thin, empty shell. Many of these shells are broken up in threshing and blow away with the chaff. This sometimes accounts for a crop of seed giving such a low yield when it seemed to be full of seed. Some of the infected seed remains with the sound seed, but of course, is worthless.

Apparatus. Samples of infested clover seed as it came from the threshing machine, and a tripod magnifier.

Procedure. Examine clover seed for traces of the above insect. If you examine carefully ,you will find larvae of this pest in some of the affected seed, while others will be empty. Describe what you find. Examine heads of clover in the fields if possible. Discuss how best to control this pest.

EXPERIMENT NO. 70.

CLOVER CROP PESTS.—ROOT-BORER.

Discussion. A field of red clover in bloom is alive with insects. Such profusion of insects of different kinds possibly does not frequent any other crop. More than 200 species of insects may be found on red clover and more than half of them feed on some part of the plant. They attack all parts of the plant, root, stem, leaves and seed alike. Some of the insects are beneficial, and while most of them do no great damage their total ravages each year considerably lessen both the hay and seed crop. There are but seven of the most harmful clover pests and they can be controlled by proper care without any additional expense. In this experiment we will study the root borer.

Apparatus. Clover plants dug from an old clover field, and a magnifier.

Procedure. Plants attacked by the clover root-borer wilt and finally die, appearing as if suffering from drought or disease. When pulled, if badly infested, the plant breaks off at the surface of the ground. In dry weather the plant is soon killed by the borer, while in wet weather it may continue to live for some time. The borer causes the plant to bloom irregularly and greatly lessens the seed crop. The beetle is a small brownish black bug, and may be found by tearing open the crowns of the clover. It may be found most easily during mid-summer, but is also present all fall and winter. Take the clover crowns, tear them open, look for holes made by the beetle and for the beetle itself. The holes will appear as brown rot streaks throughout the crown. Find out about the life history of this pest and see in what localities it is common. See if you can find insects in pupae or larvae stage. Discuss the methods of control.

EXPERIMENT NO. 71.

CLOVER CROP PESTS.—SEED-MIDGE.

Discussion. This pest prevents the formation of seed. The maggot of this tiny insect enters the flower bud and feeds upon the undeveloped seeds. When times comes to harvest the seed crop there is no seed, for there were none left to mature. This fly-like insect in the adult stage can scarcely be seen when flying, but its red markings catch the eye when the insect alights. To determine the presence of this insect go into the clover field while the clover is blooming if possible, or if performed in the winter, use clover heads from the mow.

Apparatus. Heads of clover from the hay mow; heads of clover partly in bloom and partly green sealed in a glass jar, and a tripod magnifier.

Procedure. If the heads of green clover are placed in a glass jar and sealed, when shaken the seed midge will emerge from the blossoms and the number present in the clover may be estimated very accurately. The pupa of the insect may often be found in the heads of clover during the winter. Observe the clover heads you have and see if you can find in the little flowerlets traces of this insect.

Write a discussion upon Clover Crop Pests.

EXPERIMENT NO. 72.

CORN CROP PESTS.

Discussion. To be able to identify the insect pests of corn is the first and most necessary step in eradicating them and it is of great economic value to any community when the residents know by sight the insects which they have to combat.

Apparatus. A field of corn.

Procedure. (1) Corn Root-Worm. The corn-root worm can be found from late June to August. Go into the field during this time and find the worm. This worm is responsible for greater loss to the corn crop than all other pests put together, and because it is so small and does its work underground, it is almost if not entirely unknown to the average farmer. A full sized worm is about one-third of an inch long and as large around as a pin. It is whitish in color, except the head, which is brown. The worm hatches about the last of June in the Northern states and reaches the pupa stage by the first of August. In a few days after this it emerges from the pupa stage, a small green beetle.

The beetles of the corn-root worm appear in rather large numbers during the last of August and first of September. Go into the corn field and secure several beetles. They are green in color and about twice the size of a pinhead. Learn to distinguish the beetles at sight.

Obtain a number of the pupae of the corn-root worm from around the roots of the corn stalk about the first of August. Place some of them in a jar of warm moist soil, keeping the lid loosely fastened. Watch for the beetles to appear. Place others of the pupae in a small vial of water and formalin as previously explained. Label them and place them with your other exhibits.

FIELD EXERCISE.—CORN EAR WORMS.

Corn Ear Worms. Secure samples of corn in which the ear worm has been present. How does the worm attack the corn? Make a study of the worm and be able to identify it at sight. If possible, secure also samples of the cutworm, corn-root aphis and the wire worm. Place each in a small vial and cover with water to which a spoonful or two of formalin has been added. Seal tightly, label each, and place them in your collection of School Agricultural Exhibits.